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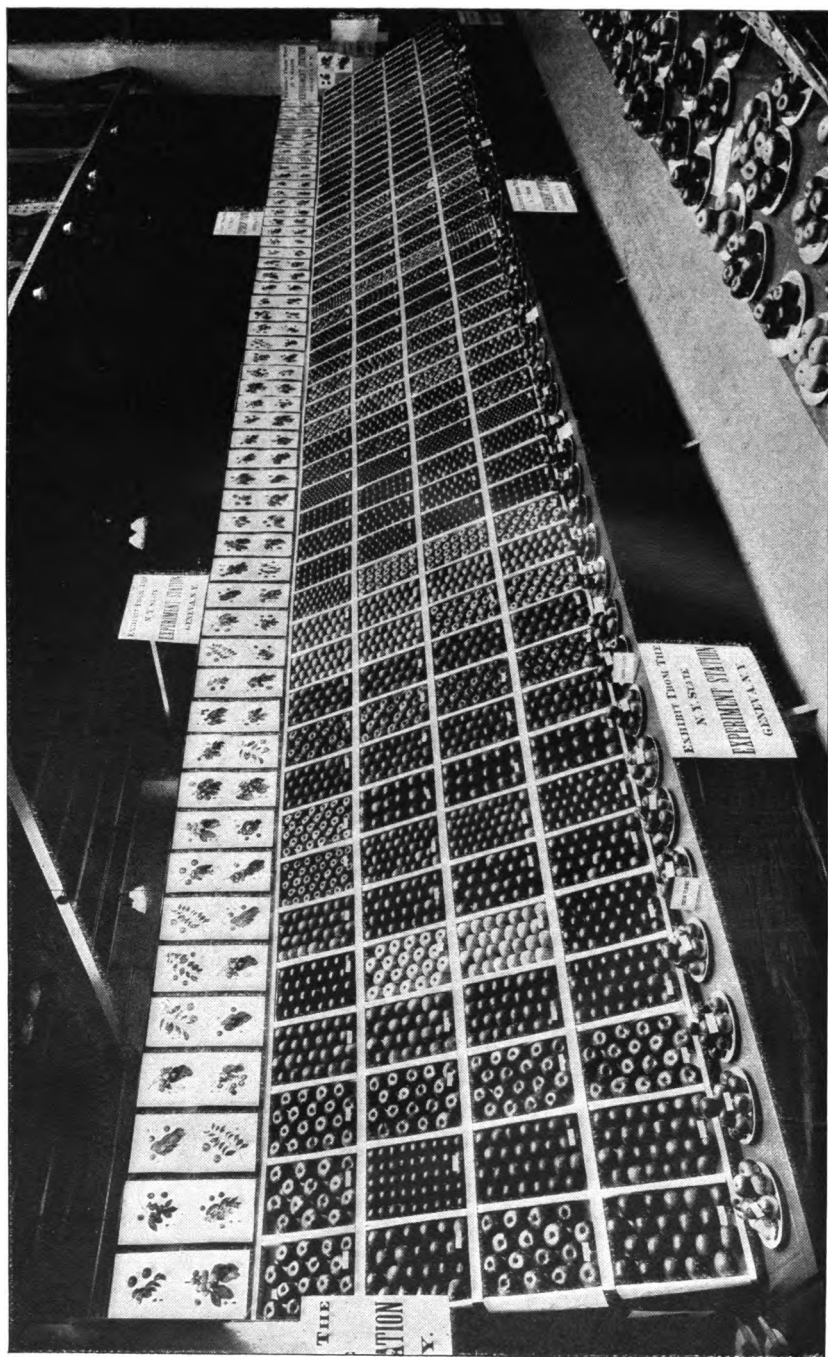
Annual Report

New York (State) Dept. of Agriculture

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APPLES SHOWN BY STATION AT MEETING OF NEW YORK STATE FRUIT GROWERS.

State of New York—Department of Agriculture.

THIRTIETH ANNUAL REPORT

OF THE

New York
Agricultural Experiment Station
(GENEVA, ONTARIO COUNTY)

FOR THE YEAR 1911

With Reports of Director and Other Officers

TRANSMITTED TO THE LEGISLATURE JANUARY 15, 1912

ALBANY
THE ARGUS COMPANY, PRINTERS
1912

STATE OF NEW YORK

No. 20.

IN ASSEMBLY

JANUARY 15, 1912.

THIRTIETH ANNUAL REPORT

OF THE

BOARD OF CONTROL OF THE NEW YORK AGRICULTURAL EXPERIMENT STATION

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January 15, 1912.*

To the Assembly of the State of New York:

I have the honor to submit herewith the Thirtieth Annual Report of the Director and Board of Control of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

R. A. PEARSON,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION.

W. H. JORDAN, *Director.*

GENEVA, N. Y., *January 12, 1912.*

Hon. R. A. PEARSON, *Commissioner of Agriculture, Albany,*
N. Y.:

DEAR SIR.— I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1911.

Yours respectfully,

T. B. WILSON,
President Board of Control.

Esch.
N. Y. Public Library
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BOARD OF CONTROL.

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WILLIAM P. WHEELER, *First Assistant (Animal Industry).*
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1 HAROLD J. CONN, PH.D., *Associate Bacteriologist.*
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3 JAMES K. WILSON, B.S.,
4 GODFREY L. A. RUEHLE, M.S., *Assistant Bacteriologists.*
FRED C. STEWART, M.S., *Botanist.*
5 JOHN G. GROSSENBACHER, PDB., A.B., *Associate Botanist.*
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6 ALFRED W. BOSWORTH, B.S.,
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8 JAMES T. CUSICK, B.S.,
OTTO MCCREARY, B. S.,
9 ORBIN B. WINTER, B.S., *Assistant Chemists.*
GEORGE A. SMITH, *Dairy Expert.*
FRANK H. HALL, B.S., *Editor and Librarian.*
PERCIVAL J. PARROTT, M.A., *Entomologist.*
WILLIAM J. SCHOENE, *Associate Entomologist.*
HAROLD E. HODGKISS, B.S., *Assistant Entomologist.*
ULYSSES P. HEDRICK, M.S., *Horticulturist.*
10 W. H. ALDERMAN, B. S. AGR.,
11 RICHARD WELLINGTON, B.S., *Associate Horticulturist.*
GEORGE H. HOWE, B.S.A.,
12 CHARLES B. TUBERGEN, B.S., *Assistant Horticulturists.*
ORBIN M. TAYLOR, *Foreman in Horticulture.*
13 JOSEPH F. BARKER, M.S., *In Charge of Soil Investigations.*
14 F. ATWOOD SIRRINE, M.S., *Special Agent.*
15 JENNIE TERWILLIGER, *Director's Secretary.*
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LENA G. CURTIS,
AGNES E. RYAN,
16 ESTHER F. HAWKINS, *Clerks and Stenographers.*
ADIN H. HORTON, *Computer and Mailing Clerk.*
17 FRED Z. HARTZELL, M.A., *Assistant Entomologist.*
17 FRED. E. GLADWIN, B.S., *Special Agent.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

- ¹Appointed Aug. 1, 1911.
²Resigned June 30, 1911.
³Absent on leave after Oct. 20, 1911.
⁴Appointed Feb. 25, 1911.
⁵Absent on leave after Nov. 1, 1911.
⁶Absent on leave after Oct. 16, 1911.
⁷Appointed Aug. 29, 1911.
⁸Returned from absence on leave June 10, 1911.
⁹Appointed Aug. 16, 1911.
¹⁰Resigned Aug. 1, 1911.
¹¹Appointed Associate Horticulturist June 19, 1911.
¹²Appointed July 1, 1911.
¹³Appointed July 10, 1911.
¹⁴Riverhead, N. Y.
¹⁵Returned from absence on leave Sept. 20, 1911.
¹⁶Appointed Oct. 16, 1911.
¹⁷Connected with Chautauqua Grape Work.

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THIRTIETH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *October 1, 1911.*

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1911:

MAINTENANCE FUND — NECESSARY EXPENSE.

APPROPRIATION 1910-1911.

1910.	<i>Receipts.</i>	<i>Dr.</i>
Oct.	1. To balance on hand.....	\$2,434 41
	To amount received from Comptroller..	22,500 00
		\$24,934 41

1910.	<i>Expenditures.</i>	<i>Cr.</i>
Oct. 1.	By building and repairs.....	\$484 71
	By chemical supplies.....	903 56
	By contingent expenses.....	2,850 67
	By feeding stuffs.....	1,877 53
	By fertilizers	351 88
	By freight and express.....	754 97
	By furniture and fixtures.....	161 92
	By heat, light and water.....	925 81
	By library	958 73
	By live stock.....	5 00
	By postage and stationery.....	1,437 12
	By publications	6,024 48
	By scientific apparatus.....	305 99
	By seeds, plants and sundry supplies...	2,084 81
	By tools, implements and machinery...	450 06
	By traveling expenses.....	2,674 11
1911.		
Oct. 1.	By balance	2,683 06
		\$24,934 41

GENERAL EXPENSE — HEAT, LIGHT, WATER, ETC.

APPROPRIATION 1910-1911.

1910.	<i>Receipts.</i>	<i>Dr.</i>
Oct. 1.	To balance on hand.....	\$52 56
	To amount received from Comptroller..	5,500 00
		\$5,552 56

NEW YORK AGRICULTURAL EXPERIMENT STATION. 3

1910.	<i>Expenditures.</i>	<i>Cr.</i>
Oct.	1. By building and repairs.....	\$2,630 33
	By heat, light and water.....	2,472 29
	By tools, implements and machinery...	145 03
1911.		
Oct.	1. By balance	304 91
		\$5,552 56

SPECIAL FUND — HORTICULTURAL INVESTIGATIONS.

APPROPRIATION 1910-1911.

1910.		<i>Cr.</i>
Oct.	1. To balance on hand.....	\$18 27
1911.		<i>Dr.</i>
Oct.	1. By balance on hand.....	18 27

SALARIES.

1910.	<i>Receipts.</i>	<i>Cr.</i>
Oct.	1. To balance on hand.....	\$2,341 81
	To amount received from Comptroller..	47,000 00
		\$49,341 81

	<i>Expenditures.</i>	<i>Dr.</i>
	By salaries	\$43,767 73
1911.		
Oct.	1. By balance	5,574 08
		\$49,341 81

LABOR.

1910.	<i>Receipts.</i>	<i>Dr.</i>
Oct.	1. To balance on hand.....	\$661 18
	To amount received from Comptroller..	15,800 00
		\$16,461 18

	<i>Expenditures.</i>	<i>Cr.</i>
	By Labor	\$15,602 62
1911.		
Oct.	1. By balance	858 56
		\$16,461 18

FERTILIZER INSPECTION.

1910.	<i>Receipts.</i>	<i>Dr.</i>
Oct.	1. To balance on hand.....	\$8 16
	To amount received from Comptroller..	10,000 00
		\$10,008 16

	<i>Expenditures.</i>	<i>Cr.</i>
	By chemical supplies.....	\$412 75
	By contingent expenses.....	1 75
	By freight and express.....	84 28
	By heat, light and water.....	222 80
	By postage and stationery.....	2 05
	By publications	1,776 06
	By salaries	7,159 10
	By seeds, plants and sundry supplies...	50
	By traveling expenses.....	239 76
1911.		
Oct.	1. By balance	109 11
		\$10,008 16

CONCENTRATED FEEDING STUFFS INSPECTION.

1910.	<i>Receipts.</i>	<i>Dr.</i>
Oct.	1. To balance on hand.....	\$386 44
	To amount received from Comptroller..	3,500 00
		\$3,886 44

	<i>Expenditures.</i>	<i>Cr.</i>
	By chemical supplies.....	\$94 40
	By freight and express.....	28 96
	By heat, light and water.....	74 90
	By publications	1,595 08
	By salaries	1,994 27
1911.		
Oct.	1. By balance	98 83
		\$3,886 44

CHAUTAUQUA GRAPE INVESTIGATION FUND.

1910.	<i>Receipts.</i>	<i>Dr.</i>
Oct.	1. To amount received from Comptroller.	\$6,030 03

	<i>Expenditures.</i>	<i>Cr.</i>
	By building and repairs.....	\$75 00
	By chemical supplies.....	23 69
	By contingent expenses.....	985 62
	By fertilizers	164 81
	By freight and express.....	37 13
	By furniture and fixtures.....	2 00
	By heat, light and water.....	25 27

REPORT OF THE TREASURER OF THE

1910.	<i>Expenditures.</i>	<i>Cr.</i>
Oct.	1. By labor	\$47 75
	By postage and stationery	73 26
	By publications	393 98
	By salaries	3,247 36
	By scientific apparatus	7 55
	By seeds, plants, and sundry supplies	444 34
	By tools, implements and machinery	66 23
	By traveling expenses	436 04
		\$6,030 03

	<i>Insurance Money.</i>	<i>Dr.</i>
1910.		
Oct.	1. To balance on hand	\$22 07
1911.		<i>Cr.</i>
Oct.	1. By balance on hand	22 07
	Remitted to the Treasurer of the State of New York (received from railroad company for damages to nursery stock in transit)	22 25

UNITED STATES APPROPRIATIONS — 1910-1911.

HATCH FUND.

	<i>Receipts.</i>	<i>Dr.</i>
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1911, under act of Congress approved March 2, 1887		\$1,500 00

Expenditures.

	<i>Cr.</i>
By salaries	\$726 01
By labor	762 44
By seeds, plants and sundry supplies...	11 55
	\$1,500 00

ADAMS FUND.

Receipts.

Dr.

To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1911, under act of Congress approved March 16, 1906	\$1,500 00
---	------------

Expenditures.

Cr.

By salaries	\$1,500 00
-------------------	------------

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forwarded to the Comptroller of the State of New York.

(Signed) W. O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1911.*

To the Honorable Board of Control of the New York Agricultural Experiment Station.

GENTLEMEN.—I have the honor to submit herewith a report of this institution for the year 1911. This includes, among other matters, the expenditures for the fiscal year ending September 30, 1911, a statement of the needs of the Station in view of the enlarging demands made upon it, and a brief review of the main results obtained, as shown in full in the text of the complete bulletins which make up the body of the report.

ADMINISTRATION.

THE STATION STAFF.

During the past year the following persons have absented themselves from the Station for the purposes of further study:

Martin J. Prucha, Associate Bacteriologist, and James K. Wilson, Assistant Bacteriologist, are pursuing biological studies at Cornell University.

Alfred W. Bosworth, Associate Chemist, is resident at Harvard University giving especial attention to biological chemistry.

Notwithstanding the desirability of granting such leaves of absence for the purpose of further study, it cannot be denied that this policy may easily do serious harm to the work the Station is carrying on, through the interruption of the study of problems that must be under consideration during long periods of time. It is for this reason that your Board adopted the rule that an assistant or associate of the staff shall not be granted a leave of absence until he has been resident at the Station for at least three years.

It is worthy of note that during the past three years ten of the younger members of the staff have withdrawn from the Station, either temporarily or permanently, in order to pursue advanced

* A reprint of Bulletin No. 342, December, 1911.

study. For this purpose they have sought the advantages of the larger centers of learning and have distributed themselves among the following universities: Chicago, Columbia, Cornell, Harvard, Wisconsin and Yale.

It is a significant fact that these young men came to see their need of larger scientific knowledge in special directions rather than a greater familiarity with agricultural practice. This is testimony to the fact that, other things being equal, the man best equipped for agricultural investigation is the man most severely grounded in the fundamental sciences. The agricultural technics related to any line of inquiry are more easily acquired outside of college halls than is the necessary scientific training. Indeed, the practice side of agricultural investigation is nowhere so well learned as in the midst of practice. As related to future efficiency, it is a matter for congratulation when young men seek larger acquirements, and it is gratifying to believe that the Station environment has been such as to stimulate their ambitions in this direction.

The following appointments have been made to the Staff:

Rudolph J. Anderson, B. S., as Associate Chemist. Mr. Anderson graduated from Tulane University in 1906. For several years he was engaged in pharmaceutical work. The last two years previous to his appointment were spent in advanced study at the Universities of Upsala and Berlin, chiefly at the latter.

Joseph F. Barker, M. S., in charge of soil investigations. Mr. Barker is a graduate of the Ohio State University in the class of 1908. As a result of graduate study in the Iowa State College he was granted the degree of M. S. by that institution in 1910. At the time of his election to the Station Staff he held the position of Assistant Professor of Agronomy in the Iowa State College.

Harold J. Conn, Ph. D., as Associate Bacteriologist. Dr. Conn took his undergraduate course at Wesleyan University. Later he spent three years in advanced study at Cornell University, chiefly in soil bacteriology, in consideration of which the degree of Ph. D. was conferred on him in 1911.

Godfrey L. A. Ruehle, M. S., as Assistant Bacteriologist. Mr. Ruehle is a graduate of Washington University (Seattle), class of 1908. He was given the degree of M. S. by the same institution in 1910.

Orrin B. Winter, B. A., as Assistant Chemist. Mr. Winter is a graduate of the University of Michigan, class of 1909. At the time of his appointment he was serving as Assistant Chemist in the Michigan Agricultural Experiment Station.

MAINTENANCE FUNDS.

The State appropriations for the maintenance of the Station during the fiscal year ending September 30, 1911, were as follows:

Salaries	\$47,000 00
Labor	15,800 00
Maintenance of the work of the Station departments	22,500 00
General expense, heat, light, water, repairs, etc.	5,500 00
Total	<u>\$90,800 00</u>

Expenses of chemical work in analyzing samples of fertilizers and feeds submitted as required by law by the Commissioner of Agriculture:

Fertilizer inspection	\$10,000 00
Feeding stuffs inspection	3,500 00
Total	<u>\$13,500 00</u>

For investigating the conditions affecting the grape industry in Chautauqua county \$7,500 00

The following are the appropriations for the current fiscal year:

Salaries	\$52,000 00
Labor	15,800 00
Maintenance of the work of the Station departments	22,500 00
General expense, heat, light, water, repairs, etc.	5,500 00
Total	<u>\$95,800 00</u>

Expense of chemical work in analyzing samples of fertilizers and feeds submitted as required by law by the Commissioner of Agriculture:

Fertilizer inspection	\$10,000 00
Feeding stuffs inspection	3,500 00
Total	<u>\$13,500 00</u>

The appropriations for 1911-12 are less by \$16,700 than the amount requested by your Board. The sum of \$5,000 was added to the salary item, but the other items were finally made the same as for the previous year, excepting that the appropriation for investigating grape problems was cut out entirely. Any considerable increase of one item alone, as occurred with that for the payment of salaries, throws the maintenance funds out of balance because an addition to the working force of an institution necessitates a larger expenditure for apparatus, traveling, printing and so on.

THE PURCHASE OF ADDITIONAL LAND.

The Legislature of 1911 made a much needed appropriation of \$15,500 for increasing the experimental area at the Station. This appropriation has been used in the purchase of the so-called Crittenden Farm located in the town of Geneva and cornering on the northwest corner of the Station property. This farm contains about eighty-seven acres, all of which is of excellent quality and is all available for crop and fruit production. There are on the property two dwelling houses, one of which can be made to house comfortably three small families. These houses will prove very useful in enabling the Station to accommodate its workmen.

Already fifty-three acres of the farm are occupied by field and orchard experiments that would not be possible under previous conditions.

NEEDS FOR THE FISCAL YEAR 1911-12.

The demands upon the modern agricultural agencies sustained by the nation and state are constantly increasing and in many directions. Any scientific institution that serves the complex agricultural interests of a State like New York must consider a great variety of problems that pertain to general farming, dairying, fruit growing and other special lines. This requires the attention of a fairly large group of specialists, and increasingly so. With an increase in the number of a station staff the expenses of operation correspondingly increase. It is the policy of the

State of New York to classify its appropriations to this institution under several heads such as salaries, labor, maintenance expenses and so on. For the current fiscal year the funds for labor and those providing for the maintenance of the Station activities are too small in proportion to the salary fund. For this reason an increase is requested in the appropriation items assigned to labor and maintenance of departments.

The fund assigned to fertilizer analyses and to the publication of results is now insufficient to do this work as thoroughly as it should be done. It is now desired to study the forms in which nitrogen exists in the various brands of fertilizers, a most essential part of the inspection, for which a method has recently been devised and which is time-consuming. Another chemist should, therefore, be placed in the fertilizer laboratory in order to extend the analyses into this new field.

Similar conditions prevail in the inspection of feeding stuffs. Recent changes in the law governing this inspection make both chemical and microscopical examinations necessary, the object of the physical examination being to ascertain the nature of the ingredients out of which the feeding stuffs are compounded. Such examinations require much time on the part of a competent chemist and nearly double the work of inspection. More funds are needed in this direction. The expense of the fertilizer and feeding stuff bulletins is large, amounting with each to \$1,500 to \$1,800 annually.

Repairs.—The amount expended in repairs during the next year should be considerable. The chemical laboratory has practically gone without repairs since its erection in 1891-2 and it should be neglected no longer. All the Station buildings should be painted in 1912. Some of the buildings acquired by the Station in connection with the new farm are in need of repair. In all, considerable more money than is available in the maintenance funds of the Station is needed for these several repairs. An item of \$6,000 is asked for in the supply bill in order that funds may be available before the next fiscal year begins.

INVESTIGATIONS RELATING TO THE GRAPE INDUSTRY IN CHAUTAUQUA COUNTY.

The Legislature of 1909 authorized an investigation into the conditions of grape growing in Chautauqua county and made an initial appropriation of \$10,000 for that purpose. It is obvious that such an investigation into methods of culture, varieties of grapes and the suppression of fungus and insect pests not well understood must necessarily cover a period of years if reliable conclusions are to be reached. The Station promptly entered upon its work and in pursuance of a carefully considered plan leased land for a period of ten years, and located a squad of men in the county to study special problems. The Legislature of 1910 continued to support this effort by an appropriation of \$7,500. In 1911 a similar appropriation passed the Senate and Assembly but was disapproved by the Governor. Fortunately a sufficient balance existed from the previous appropriation to carry on the work until February or March, 1912, and if at that time no further funds are provided the work must be discontinued. It is advised that a special bill should be passed early in this session of the Legislature providing for the work until the beginning of the next fiscal year, as an item in the supply bill would not be available sufficiently early. The amount needed would be approximately \$4,000.

NEW BUILDING.

For four successive years the need of a new building at this institution has been presented to the Legislature. The Legislatures of 1909 and 1910 passed bills making an appropriation for an Administration and Demonstration building, but in both instances the bill failed to receive the Governor's signature. The reasons why this building should be provided are restated here as given in my report for 1910:

(1) There is no place at the institution where an audience can be assembled, excepting out of doors in the pleasant days of the

warm season. This is wrong; for the work of the Station stands in such relation to educational interests and farm practice that some way of assembling audiences on the Station ground and bringing them into close range with the Station activities and results should be made possible.

(2) It is extremely desirable that space shall be provided where the results of Station work can be illustrated in a concrete form. We have many visitors who state that they come to see what the Station is doing, not realizing that in the progress of our inquiries they can only see a single point in the progress of an experiment or investigation, which to the untrained eye may be meaningless.

Space is needed for the objective display of results that have been reached in dairy work, in the study of farm pests, field experiments and in other directions. Such an exhibit would be especially useful and instructive in connection with meetings here of horticultural societies and other bodies interested in special lines of production.

(3) The number of the scientific staff is now such that more office room is needed. This can be provided by removing the museum collections in the building now occupied by the departments of bacteriology, botany, dairying, entomology and horticulture, to the proposed new building.

(4) The building now used for administrative and library purposes is needed for other uses. It has come to be necessary to arrange for boarding the unmarried members of the staff at some point nearer than the city. Rooms are now available on the Station grounds, but arrangements for meals near the Station are now difficult and uncertain, sometimes impossible. With slight expense the building now used for offices and library could be adapted to the uses indicated and it would be a much needed convenience. Getting a noon lunch a mile or mile and a half away occasions either much loss of time or such haste as is equally detrimental to health and good work.

APPROPRIATIONS DESIRED FOR THE FISCAL YEAR 1912-13.

For salaries (resident scientific and clerical staff).....	\$52,000 00
For labor	17,000 00
Maintenance of the work of the various Station departments...	25,000 00
General expense, heat, light, water, repairs, etc.....	5,500 00
For conducting grape investigations in Chautauqua County (salaries and expenses).....	7,500 00
Expense of chemical analysis of samples of fertilizers and feeds submitted as required by law by the Commissioner of Agri- culture:	
Fertilizer inspection	12,000 00
Feeding stuffs inspection.....	5,000 00
Administration and demonstration building.....	60,000 00

PUBLICATIONS.

Bulletins in the two forms, complete and popular, are now issued approximately as follows:

Popular Bulletins.

Residents of New York.....	39,000 00
Residents of other states.....	2,815 00
Newspapers	785 00
Experiment stations and their staffs.....	1,514 00
Miscellaneous	100 00
Total	<u>44,214 00</u>

Complete Bulletins.

Experiment stations and their staffs.....	1,514 00
Libraries, scientists, etc.....	245 00
Foreign list	308 00
Individuals	4,018 00
Miscellaneous	100 00
Total	<u>6,185 00</u>

The Plums of New York, the third in the series of fruit publications, is now ready for distribution. The edition is 9,000 copies, 5,000 copies of which are delivered to members of the Legislature, 2,000 copies to the Commissioner of Agriculture and 2,000 to this institution. Persons desiring this work may note that the chances of getting a copy from their members of the Legislature are more than twice as great as they are by request of the Station. The effort is made to confine the distribution of the Station copies to libraries, schools, teachers and those persons actually interested in a material way in plum culture. It is a

misuse of these volumes to send them to those who simply wish to possess a fine book containing attractive pictures. Attention is again called to the fact that second-hand book stores are liberally supplied with these fruit publications which they dispose of at very generous profits. This constitutes a prostitution of State funds.

The preparation of other publications in this fruit series is now underway, the completion of which must not be expected for several years.

A NEW DEPARTMENT.

The election to the Station staff of a specialist in soil investigations means a much fuller development of soil studies than has heretofore been possible. A soil investigation laboratory has been equipped and the organization of field work has begun in Chautauqua county and on the new farm recently purchased. It is hoped that field work will be developed in other parts of the State.

A wide difference of opinion exists as to the place and value of field experiments in a search for knowledge concerning soil management and crop production. It is significant that the fundamental knowledge we now possess is largely the result of laboratory studies. What we know of the essential constituents of plants, the supply of plant food in the soil, losses from the soil under varying conditions, the influence of soil texture upon temperature and water supply, soil inoculation for the growth of legumes and other important facts and principles has come almost entirely from chemical and bacteriological studies. The results of field experiments are end results that are influenced by a great number of factors such as soil composition and texture, water supply, soil flora and climatic conditions, a situation so complex that it is practically impossible to assign to any one factor its relative influence upon crop production in any particular field experiment. Field experiments show that in a certain locality with a given soil, different methods of treatment give different results in crop production, but as a rule these results are not self-explanatory and they may or may not serve as a guide to practice in some other

locality. The conditions of individual farms are so variable that a system of soil management must usually be developed on the basis of general principles rather than by imitating practice that is successful in some other locality.

Long time field experiments give the most reliable results, but it is worth while inquiring as to the extent that the Rothamstead field work covering sixty or more years, and the work at the Pennsylvania State College for nearly thirty years, will serve as a guide to practice in general, excepting as the long-continued treatments furnish an opportunity for important chemical and bacteriological studies. It is the business of a scientific agency working in the interests of agriculture to search out fundamental facts and principles and anything less than this smacks of empiricism.

CHAUTAUQUA GRAPE INVESTIGATIONS.

The financial status of this enterprise has already been presented. The work as outlined in my report for 1910, especially as summarized in Bulletin No. 331, has been somewhat enlarged. Soil experiments have been instituted under the direction of Mr. Barker, with especial reference to drainage, deep tillage and the introduction of large quantities of lime and fertilizer when vines are set. It is believed that the results already reached in the control of fungus and insect pests repay many times the expenses incurred. The culture experiments will not furnish a basis for intelligent comment until after several years.

WHY AGRICULTURAL INVESTIGATION IS EXPENSIVE.

The question is often asked by those not especially familiar with the methods of scientific investigation why this investigation is so expensive, in other words, why does an experiment station need so much money in order to maintain its activities? This question can best be answered by a description of the way in which certain problems must be studied in order to reach a solution that is worth while.

Just now the Department of Bacteriology is engaged in a study of the effect of certain factors upon the sanitary quality of milk, including the milking machine, form of milk pail, cleanliness of cow and of the milker, condition of the interior of the stable and other factors. This inquiry will necessarily cover two or more years, during which time a very large number of cultures of bacteria must be made and counted, requiring the laboratory time of one man while the work is going on, besides much attention to barn details.

The knowledge we now have of the chemistry and bacteriology of cheesemaking is the cumulative result of several years of careful chemical and bacteriological investigations.

The matter of the economical manufacture and efficient use of lime-sulphur wash has employed two chemists during several months with experimental mixtures, and the field studies have involved the spraying of a large number of trees with close and extended observations as to results.

The study of a new plant disease sometimes requires the attention of an investigator during two or more seasons, as has been the case with currant blight or wilt. It was necessary in this inquiry to make laboratory cultures, perform numerous inoculation experiments and carry on a series of field observations. The degree of control that has been secured over apple scab and potato blight was made possible first of all through elaborate botanical studies and later through a long series of experiments with various fungicides.

The depredations of a new injurious insect must be attacked first of all by a study of its life history, the transformations into the four stages of life covering a whole year, with the necessity of sometimes repeating the observations. The field of inquiry must then be transferred from the laboratory to the field in order to test means of prevention.

The Horticultural Department is engaged in extensive plant-breeding work. There is first the careful processes of pollinization, then the growth of the vine, shrub or tree to the time of

fruiting, with careful observations all along the line. A fertilizer experiment with fruits covering a period of fifteen years has just been reported. The data given include the yield of fruit, the size of stems and twig and leaf growth, to say nothing of culture and the application of experimental fertilizers during the period of time mentioned.

Several years ago the Station took up the much-discussed question of the food source of milk fat which no former inquiry had fully answered. It was necessary to provide food from which the fat had been extracted, analyze it, feed cows on weighed rations for several months, weigh and analyze the milk during this time and collect, weigh and analyze the feces and urine.

The above are but types of the many problems that await solution, only a few of which can be taken up at any one time. It often happens that a single problem requires the attention of two or more men during several months or even years. Scientific investigation of the complex problems of agriculture had better not be undertaken unless it can be made severe and be carried to safe conclusions. This means that results will be reached slowly and expensively. But when we consider the immense interests affected by new knowledge that improves practice or defends the farmer against devastations, the expenditures for agricultural research seem small in comparison to the benefits derived therefrom.

INVESTIGATION.

DEPARTMENT OF BACTERIOLOGY.

Publicity and payment based on quality as factors in improving a city milk supply.—In Bulletin No. 337 are recorded the results of a study of the influence upon a city milk supply of publicity regarding the sanitary conditions under which the milk was produced and of payment to the producer on the basis of the sanitary quality of the product.

In comparing dairies the sanitary conditions surrounding the production and handling of the milk were reduced to a numerical basis by means of a score card. In order to make these numerical

results easily understood they were grouped under the following heads: Poor, including filthy conditions; medium, where conditions were merely dirty; good, where the conditions were fairly clean; excellent, where they were both clean and sanitary.

There is every reason for thinking that the sanitary conditions of this city supply at the beginning of this study were as good as the average of the cities of the State. A careful initial inspection showed that 37.5 per ct. of the dairies were "poor," 57.5 per ct. "medium" and 5 per ct. "good."

At the end of one year 2.9 per ct. of the dairies ranked as "excellent," 58.9 per ct. as "good" and 38.2 per ct. as "medium."

At the end of the second year 8.6 per ct. of the dairies ranked as "excellent," 82.8 per ct. as "good" and 8.6 per ct. as "medium."

At the end of the third year 12.8 per ct. of the dairies ranked as "excellent," 74.4 per ct. as "good" and 12.8 per ct. as "medium."

At the end of the first quarter of the fourth year 12.8 per ct. of the dairies ranked as "excellent" and 87.2 per ct. as "good," the "medium" grade having finally disappeared.

While a lack of co-operation between the health authorities and the milkmen is ordinarily the factor which retards improvement in city milk supplies, the limit of improvement is set by the disinclination of the consumer to pay a fair price for the labor and expense necessary in the production and sale of clean milk.

DEPARTMENT OF BOTANY.

Seed testing.—As announced in Bulletin No. 333, samples of agricultural seeds sent to the Station will be tested for purity free of charge. During 1910, 947 samples were tested—566 of alfalfa, 200 of red clover, 69 of alsike clover, 13 of white clover, 77 of timothy and 22 of miscellaneous seeds. Many of the samples received were too small for a dependable analysis. Of

the alfalfa samples 11.13 per ct. and of the red clover samples 3.5 per ct. were infested with dodder. Only 4 samples (3 of alfalfa and 1 of alsike clover) were found to be adulterated. The frequent occurrence of the seed of *Centaurea repens* in the alfalfa samples indicates that much of our alfalfa seed is imported from Asia Minor. Seeds of roquette (*Eruca sativa*) were found in several samples of alfalfa seed. A few farmers have reported the occurrence of roquette in their alfalfa fields. Little is known of its capabilities as a troublesome weed.

Spraying to eradicate dandelions in lawns.—An experiment made at this Station during the past two years indicates that the spraying of lawns with a solution of iron sulphate for the purpose of eradicating dandelions is unlikely to be successful in New York. In 1909 a strip of lawn on the Station grounds was sprayed six times between April 23 and September 24 with a solution containing 1.5 pounds iron sulphate in each gallon of water. In 1910 the same strip was again sprayed six times between April 15 and June 29, using two pounds of iron sulphate per gallon. In both seasons the blooming of the dandelions was almost wholly prevented and many of the plants were killed outright by the treatment. Yet, on an area of 1,000 square feet, there were 1,085 live dandelions in July, 1910, when the treatment had to be discontinued because of the danger of ruining the lawn. After each application (with one exception) the sprayed area was black and unsightly for several days. Apparently, the treatment did not materially injure the grass during the first season; but in the second season, with more frequent applications of a stronger solution, the grass was considerably injured. The details of this work appear in Bulletin No. 335.

Potato spraying experiments.—During the season of 1910 the potato spraying experiments begun in 1902 were continued along the same lines as in previous years. The results have been published in Bulletin 338. In the ten-year experiment at Geneva six sprayings increased the yield 63 bu. per acre, while three sprayings increased it 22 bu. In the duplicate of this experiment at

Riverhead, Long Island, the gain due to five sprayings was 19 bu. per acre and to three sprayings 8.33 bu. In twelve farmers business experiments, including 218 acres, the average gain due to spraying was 19.1 bu. per acre; the average total expense of spraying was \$4.04 per acre, and the average net profit \$4.39 per acre. Five volunteer experimenters reported gains averaging 68 bu. per acre.

Currant cane blight or wilt.— This is a disease in which certain shoots or sometimes whole canes suddenly wilt and die. It is caused by a parasitic fungus, *Botryosphaeria ribis*, which attacks the canes, killing the bark and discoloring the wood. In the Hudson Valley it is very destructive. An exhaustive investigation has been made of the life history, parasitism and biology of the causal fungus and the results published in Technical Bulletin 18. This investigation has shown that three types of spores are developed on the host, although the fungus usually remains sterile in pure cultures.

When young shoots incompletely hardened are killed by new infections, the fungus usually develops its simplest spore-form on the withering tips. In early summer of the season following the blighting of bushes the dead stems exhibit numerous more or less complex, black, spore-bearing bodies broken through the outer bark. These bodies contain a second type of spore, and they commonly produce also a third type a little later.

Several fungi may appear saprophytically on the dead bushes. One of the most prevalent of the saprophytes (*Nectria cinnabarina*) has been erroneously considered the cause of the disease. As a result of the extensive inoculation experiments undertaken in this investigation, two facts require notice in this connection: (1) *Nectria cinnabarina* is not parasitic on currants; (2) associated with the causal species of *Botryosphaeria* there is a form of the fungus morphologically similar which seems usually to be a saprophyte. Early in 1908, while growing on a great variety of culture media, subcultures of the fungus obtained at different times from the pith of currant stems blighted during 1907, the

parasitic form was easily distinguished from the closely related saprophytic associate by a physiological characteristic — the pathogenic species producing a purplish-pink color on alkaline starch-paste.

Since the study of the life history of this fungus shows that the spores are produced on dead stems and branches of the host from early to late summer, and since currants seem to be most commonly infected about midsummer or a little later, it appears highly probable that the disease induced may be considerably checked or reduced by carefully pruning blighted plantations during the month of May, instead of practicing winter-pruning, as is at present customary. The prunings should be burned before the end of May, instead of allowing them to remain in heaps about a plantation throughout the summer.

DEPARTMENT OF ENTOMOLOGY.

Screening cabbage seed beds.—As has been indicated in previous reports, one of the problems being investigated by the Department of Entomology is the control of root-infesting maggots, especially those attacking the cabbage. One of the important phases of this problem is the protection of cabbage seed-beds. The Station has advocated screening as a practicable means of combating these insects, and Bulletin 334 largely deals with tests covering a period of four years with the use of cloth screens as a means of protecting cabbage seed-beds from maggots. The injury to the seed-bed not only renders the cultivation of the cabbage crop more difficult and expensive, but in some years the number of young plants destroyed is so large that farmers are frequently unable to secure the necessary seedlings for their plantings. The insects that are responsible for most of the injury are the turnip flea-beetle (*Phyllotreta vittata* Fab.) and the cabbage maggot (*Pegomya* spp.). The flea-beetles are injurious chiefly by eating round holes in the cotyledons, while the work of the maggot is confined to the roots of the young plant. Experience has shown that it is not possible to avoid losses in seed-beds by varying the

time of planting for the reason that the growth period of the plant coincides with the period during which oviposition occurs and the first brood of maggots develop. Many experiments have shown conclusively that injury by flea-beetles and maggots can be prevented by using cheesecloth of proper mesh. Besides affording protection from insects, the screen conserves the moisture and prevents baking of the soil. The young cabbage plants are shallow-rooted and very tender. They do not thrive in dry or cool weather, and the difference in screened and unscreened plants may often be attributed to more congenial conditions for growth. The plants raised under cloth grow faster during most seasons and attain the size desired for transplanting about ten days or two weeks sooner than plants grown in the customary open beds. The extra cost of screening plants ranged from 6 cents to 20 cents per 1,000 plants. In the opinion of many growers this cost is more than met by the saving in seed. In addition, some growers prefer to screen their beds because they may obtain earlier sets than from the open beds. Usually the cabbages that are set early are the first harvested and consequently bring better prices in the market.

DEPARTMENT OF HORTICULTURE.

Newer varieties of strawberries, and cultural directions.—In Bulletin No. 336 are recorded descriptions of varieties of strawberries fruiting on the Station grounds in 1909 and 1910. Severe injury by drought is emphasized by tabular statement of rainfall in June and July for the past five years. A brief description is given of the local conditions under which the plants were grown and the method of culture followed.

The important characters of both plant and fruit are fully described. The apparent value of the variety as shown by its behavior on the Station soil is given for each variety.

Special emphasis is given by summaries to those varieties which have most prominently marked such features as vigor of plants, resistance to disease, plant-making, productiveness, sex, blooming season, size of fruit, desirability.

A brief report is given of three promising seedlings sent out by this Station in 1908. The bulletin closes with general directions for the culture of strawberries, laying special emphasis on the fact that the suggestions are not specific and that details must vary in each locality to meet local conditions.

Is it necessary to fertilize an apple orchard?—This bulletin, No. 339, is a report of a fifteen-year experiment to determine whether it is necessary to fertilize apple orchards.

Current recommendations for fertilizers in orchards are unreliable because there have been few investigations of the subject which have furnished trustworthy information. Present practices are largely based on the fertilization of field and garden crops, but the needs of apples cannot be compared, in the least, with the needs of herbaceous crops because of the great differences in the habits of growth of the two kinds of plants.

This experiment has to do with apples — not apples and grass. Attention is called to this fact because most of the investigations of fertilizers for apples have been carried on with trees in sod. In all such experiments the interactions of soil, apples, grass and fertilizers are so complicated that a crucial test is impossible.

The experiment under discussion was carried on in a Station orchard, the soil of which is a clay loam too heavy for a good orchard soil and not better than the average clay soil in the farm lands of Western New York.

There are twelve plats in the experiment with fertilizers applied each year as follows:

Stable manure	Plats 1 and 9, average per tree	415.15 pounds
Acid phosphate	Plats 2 and 8, average per tree	12.66 pounds
Muriate of potash.....	Plats 6 and 10, average per tree	7.26 pounds
Acid phosphate		12.6 pounds
Muriate of potash.....	Plats 4 and 12, average per tree	7.26 pounds
Acid phosphate		12.6 pounds
Nitrate of soda.....		3.67 pounds
Dried blood		12.84 pounds

The fertilizers were put on only underneath the branches of the trees so that an excess of each has been used and the experi-

ment, therefore, throws light on the question as to whether excessive fertilization is deleterious to trees.

The apple in the experiment is the Rome top-worked on Ben Davis, the Rome buds all having come from one tree and the stocks having been selected carefully. Cross-pollination is provided for, there being over a hundred other varieties separating and bounding the plats.

The results of the experiment are gaged by the yield, size, color, flavor, maturity and keeping quality of the fruit, the diameter of tree, amount, color and weight of foliage and the length and weight and the annual growth of the branches. A summary is as follows: 1. The fertilizers have had no sensible effect upon the yield of fruit in this experiment. 2. The size of the apples is possibly increased by the fertilizers since the percentage of culls and seconds is a trifle higher in the check plats. 3. The several current generalizations as to the effects of fertilizers on apples find no verification in this experiment. 4. All of the trees in the several plats have borne crops very uniform in maturity, keeping-quality, texture and flavor of apples. 5. A study of the tables giving the diameter of the trees in the experiment shows no differences outside the range of variation in the several plats. 6. The foliage in the plats receiving nitrogen was greener than in other plats during the last season, the first difference to be certainly counted as an effect of a fertilizer. 7. There was also a measurable effect of the nitrogen in the weight of the leaves. 8. There is slight evidence that the trees on plats to which nitrogen is applied are making a greater annual growth of branches.

The fact is pointed out that there seems to be but one interpretation of the results of this experiment. At the time the experiment was begun there was, in the upper foot of soil, enough nitrogen per acre to last mature apple trees 183 years, of phosphoric acid, 295 years, of potash, 713 years. From this storehouse, tillage, cover-crops and good care have made available the plant food these trees needed. The conclusion is reached that it

may be necessary to fertilize apple orchards on sandy and gravelly soils, on lands very subject to drought, on shallow soils and on soils quite devoid of humus. Some other soils may require one of the chief elements of fertility; some, though few, indeed, need the three which usually constitute a complete fertilizer. A fruit-grower may assume that his trees do not need fertilizers if they are vigorous and making a fair amount of new wood. If the trees are not vigorous the drainage, tillage and sanitary condition of the orchard should be looked to first and the fertilization afterward if then found necessary. Lastly, before using fertilizers the fruit-grower should obtain positive evidence by experimentation as to whether an orchard needs fertilizers, and what ones.

Pruning and training the grape.—Circular No. 16 contains concise directions for pruning grapes, and photographs illustrating how grapes are pruned by several different systems. There is also a discussion of the system best adapted in various localities and for the leading varieties of grapes together with directions for making grape trellises.

Grafting and propagating plants.—Circular No. 17 discusses the propagation of plants by grafting, budding and by means of cuttings and layers. The different operations are illustrated by photographs. There is also a discussion of the best stocks for the tree fruits grown in this climate.

PUBLICATIONS ISSUED DURING 1911.

BULLETINS.

No. 333. February. Seed tests made at the station during 1910. G. T. French. Pages 16. Popular edition, pages 4.

No. 334. February. Observations on screening cabbage seed beds. W. J. Schoene. Pages 22, plates 2. Popular edition, pages 8, plates 2, fig. 1.

No. 335. March. Spraying to eradicate dandelions from lawns. G. T. French. Pages 9. Popular edition, pages 2.

No. 336. April. Newer varieties of strawberries and cultural directions. O. M. Taylor. Pages 33, plate 1, fig. 3. Popular edition, pages 15, figs. 2.

No. 337. April. Publicity and payment based on quality as factors in improving a city milk supply. H. A. Harding. Pages 26, chart 1. Popular edition, pages 11.

No. 338. May. Potato spraying experiments in 1910. F. C. Stewart, G. T. French and F. A. Sirrine. Pages 37, plate 1. Popular edition, pages 8.

No. 339. July. Is it necessary to fertilize an apple orchard? U. P. Hedrick. Pages 42, plates 4, figs. 7. Popular edition, pages 12.

No. 340. September. Inspection of feeding stuffs. Pages 99.

No. 341. October. Report of analyses of samples of fertilizers collected by the Commissioner of Agriculture during 1911. Pages 100.

No. 342. December. Director's report for 1911. W. H. Jordan. Pages 24.

TECHNICAL BULLETINS.

No. 18. July. A contribution to the life-history, parasitism and biology of *Botryosphaeria Ribis*. J. G. Grossenbacher and B. M. Duggar. Pages 78, plates 12.

CIRCULARS.

No. 16. March. Pruning and training the grape. F. E. Gladwin. Pages 8. Plates 4.

No. 17. March. Grafting and propagating plants. W. H. Alderman. Pages 8. Plates 4.

REPORT
OF THE
Department of Bacteriology.

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REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

PUBLICITY AND PAYMENT BASED ON QUALITY AS FACTORS IN IMPROVING A CITY MILK SUPPLY.*

H. A. HARDING.

SUMMARY.

1. This records the results of a study of the influence upon a city milk supply of publicity regarding the sanitary conditions under which the milk was produced and of payment to the producer on the basis of the sanitary quality of the product.

2. In comparing dairies the sanitary conditions surrounding the production and handling of the milk were reduced to a numerical basis by means of a score card. In order to make these numerical results easily understood they were grouped under the following heads: Poor, including filthy conditions; medium, where conditions were merely dirty; good, where the conditions were fairly clean; excellent, where they were both clean and sanitary.

3. There is every reason for thinking that the sanitary conditions of this city supply at the beginning of this study were as good as the average of the cities of the State. A careful initial inspection showed that 37.5 per ct. of the dairies were "poor," 57.5 per ct. "medium" and 5 per ct. "good."

4. At the end of one year 2.9 per ct. of the dairies ranked as "excellent," 58.9 per ct. as "good" and 38.2 per ct. as "medium."

5. At the end of the second year 8.6 per ct. of the dairies ranked as "excellent," 82.8 per ct. as "good" and 8.6 per ct. as "medium."

*A reprint of Bulletin No. 337. April, 1911.

6. At the end of the third year 12.8 per ct. of the dairies ranked as "excellent," 74.4 per ct. as "good" and 12.8 per ct. as "medium."

7. At the end of the first quarter of the fourth year 12.8 per ct. of the dairies ranked as "excellent" and 87.2 per ct. as "good," the "medium" grade having finally disappeared.

8. While a lack of co-operation between the health authorities and the milkmen is ordinarily the factor which retards improvement in city milk supplies the limit of improvement is set by the disinclination of the consumer to pay a fair price for the labor and expense necessary in the production and sale of clean milk.

INTRODUCTION

In all respects except quality the milk supply of the city of Geneva is fairly typical of that of the smaller cities of the State. In round numbers 13,000 people are supplied by 550 cows distributed among 40 dairies, the larger number of which are within driving distance of the city.

There is every reason to believe that in 1907, at the beginning of the studies here reported, the general quality of the milk supply was representative of that of similar cities. It was not the poor quality of the supply but rather the progressiveness of Mayor A. P. Rose which led to this attempt to study and improve its quality.

The connection of the Experiment Station with this study was indirect and unofficial. A member of the Station Staff was made a member of the Board of Health but the Station was not made responsible in any way for the acts of the Board, nor were the facilities of the Station in any way placed at its disposal.

Members of the Station Staff are studying the relative importance of the various factors that affect the quality of the milk supply. These observations bring out so clearly the importance of two factors that have not previously been studied that it seems desirable to present these factors to the public in this bulletin.

The aim of this study was to find a way by which the small city with its limited facilities may obtain as sanitary a milk supply as the largest cities with their technically trained advisers and expensive equipment.

The method employed was to score each dairy quarterly upon the basis of the sanitary conditions under which the milk was being produced, to furnish this score to the producer and retailer so that it could be made the basis of payment under their contracts, and to publish the score of all of the producers, with the names of their retailers, so that the consuming public could purchase intelligently.

ACKNOWLEDGMENTS

Thanks are respectfully rendered to the Board of Health for its permission to use the city records and to the Geneva Milk Company and the White Springs Farm Dairy Company for data of various kinds.

Recognition should also be made of the fact that the improvement in the milk supply was almost entirely due to the intelligent action of the milk producers and retailers, foremost among whom was Mr. A. G. Lewis. To him more than to any other one person was due the rapid improvement in dairy conditions, an illustration of the efficiency of a knowledge of practical affairs when employed in the highest type of social service.

If the presence of a public spirited individual in connection with the milk business was peculiar to Geneva alone there would be little hope of repeating in other cities the results here obtained. Fortunately a careful study of the milk business in practically every city will demonstrate the presence of one or more stockholders in milk handling companies, dealers or large producers who are endowed with a proper sense both of their responsibility to the public and of the business importance of handling the highest grade of product which the market will sustain. Such men will support heartily any sane business-like effort to improve conditions.

THE LOCAL SITUATION

In order to make the local situation plain the more important factors will be discussed under appropriate headings:

Ordinances.—The vital enactment under this head provides that no person shall sell milk without a license from the Board of Health and that no one shall sell milk from a dairy, the owner or manager of which refuses to permit full and frequent inspection. The penalty of losing his license and consequently his right to do business is sufficient to cause a dealer to report new dairies before undertaking to sell their product and the ability of the Board to exclude their product, if the privilege of inspection is

refused, causes all dairies to welcome inspection. In short, both parties have everything to gain and nothing to lose by obeying the ordinance.

Among the minor items in the milk business there are none of greater sanitary importance than those surrounding the collection, cleaning and refilling of the milk bottles. As handled in many of the smaller cities, the glass milk bottle is the greatest menace to the public health which exists in connection with the milk business. At present the sanitary handling of milk bottles in such cities is practically an unsolved problem, and an ordinance covering this question was not attempted.

The Inspector.— The opportunity for securing the information having been provided, the next requirement was the individual to get the facts regarding the dairies. In all New York cities this individual must be procured through a civil service commission. The most promising candidate offered by the Commission was a railroad baggage-master whose technical acquaintance with dairying was restricted to hazy recollections of his boyhood on a fruit farm. Appeals to the local and State Civil Service Commissions for a new eligible list having been refused, the man was appointed. He proved to be honest and quick to learn. Some years of observations of dairies, supplemented by a "short course" in dairying at Cornell University, transformed him into an efficient inspector. However, it was a slow and costly process. The most trying feature was the fact that this inspector was required to visit dairymen at the time when the new plan was being presented, when his extreme ignorance on dairy matters could not escape them. As a natural result, they were at first strongly prejudiced against the entire undertaking.

The importance of the Inspector having sufficient knowledge of dairying to command the respect of the dairymen should not be underestimated. The co-operation of the dairymen is essential to the success of the undertaking, and their co-operation cannot be expected as long as they believe that their dairies are being scored by a man who does not know enough about the business to judge

fairly. Until the dairymen's confidence is won, progress is extremely slow.

As a representative of the Board of Health, the Inspector should understand that his presence on the farm is a mutual courtesy and that his duty is to observe and record conditions as they exist. If he is beyond the limits of the municipality he is entirely without authority to issue orders, and the assumption by the Inspector of authority which the dairyman knows he does not possess is a common and fertile source of friction in such inspection.

The supply of dairy inspectors is smaller than the demand and the qualifications of many who are available leaves much to be desired. For satisfactory inspectors we must look to those possessing a combination of the theoretical training of the agricultural schools with practical experience in the more sanitary dairies.

Score card.—The object of dairy inspection was to collect the facts regarding the sanitary conditions under which the milk was produced for the purpose of submitting the same to the producer, the retailer and the consumer. As a means of arranging these facts so that their significance can be readily grasped by all parties, the dairy score card is the best available device.

At the beginning of this work there were, and at present there still are, a number of dairy score cards in use. Each of them has its good points and no one of them is perfect.

The card used at Geneva was devised by Dr. R. A. Pearson while he was at the head of the dairy department in Cornell University, and is known as the Cornell University Dairy Score Card. Both sides of this card as used at Geneva are reproduced on pages 37 and 38.

CITY OF GENEVA

Score Card for Production of Sanitary Milk

Date..... Dairy of..... P. O.....

Retailed by.....

		Perfect	Score	Cuts
1. HEALTH OF THE HERD AND ITS PROTECTION.	Health and comfort of the cows and their isolation when sick or at calving time...	45		.....
	Location, lighting and ventilation of the stable.....	35		.....
	Food and water.....	20		.....
	Total.....	100		
2. CLEANLINESS OF THE COWS AND THEIR SURROUNDINGS.	Cows.....	30		.....
	Stable.....	20		.....
	Barnyard and pasture.....	20		.....
	Stable air (freedom from dust and odors).....	30		.....
	Total.....	100		
3. CONSTRUCTION AND CARE OF UTENSILS.	Construction of utensils and their cleaning and sterilizing.....	40		.....
	Water supply for cleaning and location and protection of its source.....	25		.....
	Care of utensils after cleaning.....	20		.....
	Use of small-top milking pail.....	15		.....
	Total.....	100		
4. HEALTH OF EMPLOYEES AND MANNER OF MILKING.	Health of employees.....	45		.....
	Clean over-all milking suits and milking with clean, dry hands.....	30		.....
	Quiet milking, attention to cleanliness of the udder.....	25		.....
	Total.....	100		
5. HANDLING THE MILK.	Prompt and efficient cooling.....	35		.....
	Handling milk in a sanitary room and holding it at a low temperature.....	35		.....
	Protection during transportation to market.....	30		.....
	Total.....	100		
	TOTAL OF ALL SCORES.....	500		

If the total of all scores is	And each division is	The sanitary conditions are
480 or above.....	90 or above.....	EXCELLENT
450 or above.....	80 or above.....	GOOD
400 or above.....	60 or above.....	MEDIUM
Below 400.....	Or any division is below 60.....	POOR

The sanitary conditions are..... Scored by.....

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A BRIEF DESCRIPTION OF WHAT CONSTITUTES PERFECT UNDER EACH HEADING

1. **HEALTH.** No evidence of chronic or infectious disease or of acute disease in any member of the herd on the dairy premises. Freedom from tuberculosis proven by the tuberculin test made within one year.
COMFORT. Protection from weather extremes. Stall comfortable,—at least 3' wide for a small cow, or 3½' for a large cow; length of stall sufficient for cow to rest easily. Sufficient bedding. Frequent out-door exercise.
ISOLATION. Removal of cows to comfortable quarters outside of the dairy stable, when sick or at calving time.
LOCATION OF STABLE. Elevated, with healthful surroundings.
LIGHTING. As light as a well lighted living room, and with not less than four square feet for light from the east, south or west, for each cow.
VENTILATION. An adequate ventilating system of the King or other approved pattern, and, except when the stable is being cleaned, no marked stable odor.
FOOD. Clean, wholesome feeding stuffs, fed in proper quantities.
WATER. Clean, fresh water, free from possibility of contamination by disease germs.
2. **COWS.** Cleaned by thorough brushing, and where necessary by washing; no dust nor dirt on the hair (stains not considered). The udder thoroughly cleaned by brushing at least thirty minutes before milking, and by washing just before milking, leaving the udder damp to cause dust to adhere.
STABLE. Free from accumulation of dust and dirt except fresh manure in the gutter. Apart from horses, pigs, privy, poultry-house, etc.
BARNYARD AND PASTURE. No injurious plants, no mudhole nor pile of manure or any decaying substance where cows have access.
STABLE AIR. Free from floating dust and odors. Tight partitions or floor between the space occupied by cows and that used for storage of feed or other purpose.
3. **CONSTRUCTION OF UTENSILS.** Non-absorbent matter and every part accessible to the brush, and, except inside of tubes, visible when being cleaned.
CLEANING. Thorough cleaning with brush and hot water, and rinsing. No laundry soap. Thorough sterilizing.
WATER. From a source known to be pure: protected from contamination from seepage, or surface drainage.
CARE OF UTENSILS. Such as to avoid contamination by dust as well as coarser dirt.
SMALL-TOP PAIL. With opening not over seven inches in diameter, and at least one third of this opening protected by hood.
4. **EMPLOYEES.** Free from contagious disease and not dwelling in or frequenting any place where contagious disease exists.
MILKING SUITS. Freshly laundered and clean; ample to protect from dust and dirt, from the milker's person or clothing.
MILKER'S HANDS. Hands and teats dry when milking. Hands thoroughly cleaned before milking each cow.
5. **COOLING.** Cooled within fifteen minutes of milking, to temperature below 50 degrees F.
HANDLING. In a room used exclusively for handling milk, and free from dust, dirt and odors; and the milk after being cooled, always at a temperature below 50 degrees.
PROTECTION DURING TRANSPORTATION. Protected from dirt by tightly closed receptacles, temperature always below 45 degrees F.; not delayed in transit, reaching market within twenty-six hours after milking.

It is evident that this score card, without supplementary information, is too general to be of any value in the hands of an untrained inspector. To meet this situation Dr. Pearson prepared the blank reproduced below and on succeeding pages.

BOARD OF HEALTH, CITY OF GENEVA, N. Y.

MILK INSPECTION.

Dairyman Date.....
 P. O. Location.....
 No. Cows milking..... In herd..... Qts. Milk..... Cans or Bottles.....
 Milk sold to..... License No.....
 Report by..... At milking time?.....Hour.....M

 I. *Health of the herd and its protection.*

Do all cows appear healthy?.....
 Are udders sound and free from signs of disease?.....
 Are cows tuberculin tested?.....
 Date of last test?..... By whom?.....
 Number of cows added to herd since last test.....

Is the stable well built to protect from the weather?.....
 Are cows brought in during bad storms?.....
 How many hours are the cows out daily?.....
 Width of stall..... Length.....
 In the stall comfortable?..... (Rigid or swing stanchion).....
 Kind and quality of bedding?.....

Where are the cows kept when sick and at calving time?.. Comfortable?..

Is the stable well located?..... In separate stable?.....
 Comfort of place.....

Number of and size of windows..... Distribution of light.....
 Are the windows clean?.....
 Size of the stable, length.....width.....height.....
 Number of stalls.....
 How ventilated?.....

[For actual use these questions are printed in a 4-page, 8½ by 11 inch folder, the following note appearing at the top of the second page, otherwise blank:]

Sketch rough diagram, showing position of barnyard, cowstable, hay barn, out-buildings and milk room. Indicate points of compass.

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Kinds of feeds used.....

Are they of good quality and proportions?.....

Source of water for cows.....

Method of watering..... Cleanliness of troughs.....

II. *Cleanliness of the cows and their surroundings.*

Are the cows clean?..... How are they cleaned?.....

Is the hair clipped about the udder?.....

Is the udder cleaned before milking?....How?....How long before?....

Is the stable free from the accumulation of cobwebs, dirt and dust?....

Is the stable whitewashed?..... When done?.....

Kinds and number of other animals, if any, in same room with cows....

Same, adjacent rooms..... What openings, between?.....

Is the stable protected from such sources of contamination as privy, etc.?

How often is the manure removed from the stable?.....

How far is manure removed from stable?.....

Is the barnyard free from manure pile?.....And mud holes?.....

Is the pasture clean and free from injurious plants?..And mud holes?..

Is stable provided with dust-tight ceiling?..And dust-tight partitions?..

Stable floor of wood, cement or ground?.....Conditions of same?.....

Is the feeding done before or after milking?....How long before?.....

Is the floor swept or dampened before milking?...How long before?....

Is the air free from dust and odors?.....

III. *Construction and care of the utensils.*

Are all utensils such that they can be thoroughly cleaned?.....

Method of washing utensils?.....

How are the utensils sterilized?.....

How soon after use are utensils washed?.....

Is the water used for washing utensils pure?....How do you know?....

What is its source?.....

Is the source protected against contamination?.....

How are utensils cared for after cleaning?.....

Is a small top pail used for milking?.....

If so, what style and size of opening?.....

IV. *Health of employees and manner of milking.*

What evidence is there of absence of contagious disease and of exposure
of family and employees to disease?.....

Who is the family physician?

Are the milkers clean personally?.....
 Do the milkers wear clean over-all suits?.....
 How often are the over-alls washed?.....
 Where are the suits kept?.....
 Do the milkers wash their hands just before milking?.....Where?.....
 Do milkers have wet hands when milking?.....

Are milkers careful not to dislodge hair and dirt from the cow while milking?.....
 Is switching of cow's tail prevented during milking?.....

V. *Handling the milk.*

How is the milk cooled?.....
 How soon after milking is the milk cooled?.....
 To what temperature?.....

Is the milk handled in a room detached from the stable?.....
 How far from stable?.....
 What kind of floor?.....Condition of same.....
 Is the milk room used exclusively for milk, and is it free from dirt and odors?.....
 At what temperature is the milk kept after cooling?.....

How is milk cared for during transportation to market?.....

The questions in this blank are intended to cover all of the items which are of sanitary importance in all but the most unusual conditions. In practically all cases the answers are either "yes" or "no," the exceptions being where the answer is a dimension, a quantity or a temperature. This blank can be accurately filled out by any one of ordinary intelligence. Since many of the observations can best be made at milking time, the Inspector quite uniformly visited the dairies at that time, additional visits being made when circumstances indicated that it was desirable.

The facts having been recorded, the next step was to reduce them to a numerical basis. This was done by the Inspector and the author working together. At first the Inspector contributed little aside from his record. Gradually he came to take a larger part in the scoring until finally the author acted merely in an advisory capacity regarding new features and reviewed the final

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scores. In scoring, a dairy was credited as perfect in each particular unless some objectionable condition or practice was found. Deductions or cuts from the perfect score were made in accord with the following schedule, the aim being to make identical cuts for similar conditions.

SCORE CARD CUTS USED* AT GENEVA.

HEALTH OF HERD AND ITS PROTECTION.

No tuberculin test, 12.

Old tuberculin test (over one year), 12.

Rigid stanchions (not cut when cows were confined only during milking as in summer), 3.

Light, 1 to 5, according to conditions.

No special system of ventilation, 2.

Ventilation, 1 to 5.

No comfortable provision for isolation or calving outside of stable containing milking cows, 5.

Stable poorly built to protect from the weather, 1 to 5.

CLEANLINESS OF COWS AND THEIR SURROUNDINGS.

Manure or dust on cows, 1 to 10.

Hair about udders not clipped, 1.

Damp cloth not used on udders before milking, 2.

Litter or roughage on stable floor, 1 to 5.

Ceiling not tight, 1 to 5.

Cobwebs and dust in stable, 1 to 5.

Stable not whitewashed within one year, 5.

Horse in cow stable, 5.

Manure not removed once per day, 1 to 10.

Manure or mud in barn yard to which cows have access, 1 to 10.

Feeding dry feed just before milking, 1 to 10.

Objectionable odors in stable, 1 to 5.

CONSTRUCTION AND CARE OF UTENSILS.

Insufficient cleaning, 1 to 5.

No special sterilization (no steam), 5.

No. small-topped pail, 15.

HEALTH OF EMPLOYEES AND MANNER OF MILKING.

No special clean milking suits, 5.

Dirty suits, 1 to 5.

Milking with wet hands, 10.

Unclean hands, 1 to 6.

* These were the cuts as applied to actual conditions. More unsanitary surroundings would merit greater cuts than those indicated.

HANDLING THE MILK.

Not efficiently cooled (50° F. or below),

50° to 60°, cut 5.

61° to 70°, 10.

above 71°, 15.

Not held at 50° F. or below, 5.

Milk strained in stable, 5.

Milk room not clean, 1 to 5.

No milk room, 3.

Methods of publicity.—The two prime essentials in this connection are, first, that the health authorities be protected from legal responsibility for financial losses resulting from the publication of the facts; second, the results of the dairy inspection should be made accessible and intelligible to the largest possible number of people.

As will be explained, the feature of publicity was introduced in successive steps, but in its final form it met these requirements fairly successfully.

The best protection against legal action is to conduct the inspection in such an evidently impartial manner as to obtain the support of all parties. The legal phase of publicity was further provided for by the following arrangement. The Inspector reported to the Dairy Products Committee. This committee reported to the Board of Health, the report being accepted and entered in the minutes. This portion of the minutes was published by the press as a part of the proceedings of the Board.

In the matter of publicity the three classes, the producers, the retailers and the consumers were considered separately. Each producer was furnished with a carbon copy of his official score card. Each retailer was given the numerical score of the producers whose product he was handling. The consumers were reached by the quarterly publication of the standing of each producer, with the name of the retailer who was distributing the milk. The official score card for each dairy was placed on file with the clerk of the Board, where it could be easily consulted by any one who was interested.

Milk producers.— Geneva is located in a region of intense fruit cultivation and all of the milk producers are engaged in mixed farming. The number of dairies supplying milk has ranged from 30 to 40, and the number of cows has also varied. In June, 1910, the 33 dairies included 532 cows, of which somewhat less than 500 were then furnishing milk. A single large dairy contained 100 cows, the others ranging from 7 to 38 cows with an average of 13. Practically all of the dairies were located within a five-mile radius of the city and the milk was hauled in on wagons, though a few producers shipped by trolley, and after October 31st, 1910, the milk from three dairies was shipped 25 miles by rail.

The cows were mainly grades, with a predominance of Guernsey and Jersey blood, Holstein being the next most common admixture. Two of the herds furnished milk carrying approximately 5 per ct. fat. While the average fat content was not determined in connection with this study, the tests made by the State Department of Agriculture indicated an average of about 3.8 per ct. Practically every year some dairy paid the penalty for furnishing milk which was below the legal standard.

This study of the milk supply was confined to the sanitary conditions under which the milk was produced. It is recognized that production is only a part of the problem of a municipal milk supply. On the other hand, it should not be forgotten that our milk supply cannot be cleaner than at its source nor purer than when it leaves the farm. In the supply of larger cities many things may happen to milk during transportation and distribution, but in the smaller cities these elements are of much less relative importance.

Milk retailers.— At the beginning of this study milk was being distributed by 13 retailers, 5 of whom were producing a part or all of the milk that they distributed. There was one dairy company, equipped with modern facilities for cooling and handling milk, and this company was distributing the product of 11 dairies.

In 1909, 9 of the small retailers combined and established another station equipped with modern machinery. From this time until late in 1910 the milk business was handled by these two

companies, and a single retailer who produced his own milk. In November, 1910, a fourth distributor began business, handling the product of three new dairies.

Any comprehensive study of a milk supply should give considerable weight to the conditions under which milk is handled by the retailer. These conditions could undoubtedly be best compared through a score card but unfortunately there was no suitable score card available. Therefore there is no accurate record of the improvements which have been accomplished by the retailers.

At the beginning of this study each of the smaller retailers stored the milk and washed the milk utensils and containers at his home in close contact with his family. In only one of these cases was steam available in connection with the cleaning process. Now practically all of the milk is handled in central stations which are equipped with steam and modern machinery. This change marks an important step in the direction of a better milk supply.

INITIAL QUALITY IN 1907.

First inspection.—Logically, the first step was to get the facts regarding the quality of the milk supply, and this was done in September and October, 1907, by having the Inspector visit each dairy and fill out the report blanks given on pages 87-89. The Inspector left a duplicate of his report with each dairyman so that he might know exactly what was reported to the Board of Health. In only one instance was exception taken by a dairyman to an item thus reported, and this exception related to an unimportant detail.

The scores of the dairies were prepared from these blanks, supplemented by verbal descriptions by the Inspector. The points regarding which the report blanks were most deficient were the extent of the deficiency of light and ventilation, the amount of dust and cobwebs in the stable, the extent of the openings in the ceiling and the amount of dust and intensity of odors in the stable air.

Of the 40 dairies then furnishing the milk supply of Geneva the sanitary conditions of 2 ranked as "good," 23 as "medium" and 15 as "poor." The mathematical average of all of these scores was 411 points. The wide difference in individual dairies is illustrated by the cuts given to the dirtiest and the cleanest.

DIRTIEST DAIRY.		CLEANEST DAIRY.	
CUTS.		CUTS.	
No tuberculin tests	12		
Barn draughty from poor construction	10		
Drainage location bad	5		
No windows in stable.....	10		
	— 37		
Manure on cows	10		
Udders not clipped	1		
No damp cloth used on udders.	2		
Ceilings open	5		
Stable not whitewashed	5		
Cobwebs and dust	5		
Other animals in stable.....	5		
*Floor broken and littered with refuse	5		
Mud and manure in barn yard.	7		
Feeding dry feed before milking	10		
Dust and strong odor in stable	5		
	— 60		
No steam for cleaning utensils.	5		
Washed utensils left in dust..	5		
No small-topped milk pails... 15		No small-topped milk pails.....	15
No special milking suits.....	5		
	— 30		
Milk not cooled to 75° F.....	15	Milk not cooled to 60° F.....	5
No milk room	3		
No attempt at holding milk cold	10		
	— 23		
Total	155	Total	20
Dairy scores 345 and ranks as Poor.		Dairy scores 480 and ranks as Good.	

Each producer was furnished with the score of his dairy and each score card bore a list of the cuts similar to those given above.

There is no question but that any one knowing the conditions in these two dairies would be unwilling to pay the same price for the product of both and the more discriminating consumers would object to the milk from the dirtier dairy at any price. Further, it should be remembered that there were 14 more dairies in the same class with this dirtiest dairy and only 1 other in the class with the cleanest while there were 23 in the intermediate class. The mathematical average of all of the dairies was only 11 points above the turning point between "poor" and "medium."

MEETING OF BOARD OF HEALTH, MILK PRODUCERS AND MILK RETAILERS:

A meeting of the dairymen was called, the variations in the quality of the milk supply explained to them, and their co-operation in improving conditions was asked. It was explained to them that the Board did not intend to coerce them in any way, but that it intended to put the sanitary conditions surrounding each dairy fairly before the public in order that the public might be able to buy the cleanest milk that the market afforded. It was also stated that a reasonable time would be allowed the producers to adapt their methods to the new conditions before the results of the examinations were made public.

It was also suggested that inasmuch as the annual contracts between the producers and the retailers were to be made within a few months it would be desirable for both parties to have an understanding regarding the quality of milk covered by such contracts since before the year expired the retailer would be offering the product to a public which was informed concerning the sanitary conditions under which the milk was being produced.

PROGRESS IN 1908.

Second inspection.—To facilitate the making of contracts under these new conditions, a second scoring was completed early in 1908. Each producer was furnished with a copy of his own score bearing a complete list of the points for which deductions had been made, similar to those given on page 94. At the bottom of the score was written the following: "Mistakes in scoring will be cheerfully corrected." Arrows indicate points at which the score could be improved at slight expense. It would not be difficult to bring this dairy up to the — grade." These scores were furnished sufficiently in advance of the quarterly report to permit of making corrections before the final report of the Dairy Products Committee was made to the Board of Health. While only a few changes were suggested by the dairymen, these suggestions were always considered and usually followed, with the understanding that at future inspections these points must be found as represented by the dairymen. In no case did they fail to keep their word in such matters.

The first inspection for 1908, which was completed early in January, showed that in the first three months the efforts of the Board were bearing fruit. The results may be summarized as follows:

GRADING.	No. DAIRIES.
Excellent	None.
Good	7
Medium	28
Poor	3
Total	38
Average score	432 points.
Increase over previous score.....	21 points.

The two dairies which quit voluntarily were in the "poor" class. Two of the three remaining dairies in that class gave notice that they would quit with the expiration of their annual contracts, and the third dairy in the "poor" class was almost up to the

"medium" grade. The net result of this first three months of inspection was to eliminate almost completely the large supply of poor milk which had been distributed in our city in the past. This was brought about without any friction and without raising the retail price of milk.

Annual contracts partly based on quality.—The milk from five of the dairies was being retailed by the owners, who naturally had a financial interest in obtaining a high score. In the case of practically all the other dairies some more or less distinct understanding was arrived at between the producer and the retailer regarding the improvement in conditions of production which were to be made and the standard of production which was to be maintained during the year. It was this prospect of publicity coupled with the financial pressure of the new contracts that produced the marked improvement shown by this inspection.

Third inspection.—The inspection in June, 1908, showed some interesting changes, and the summary was as follows:

GRADING.	NO. DAIRIES.
Excellent	None.
Good	5
Medium	26
Poor	1
Total	32
Average score	436 points.
Increase over previous score.....	4 points.

During the interval two of the better dairies had transferred to Rochester because they could get a substantial increase in price. This price was more easily obtained on account of the high score which they had received and were able to present. Five dairies quit for business reasons, and one of desirable quality was added to the Geneva supply. An examination of the records shows that there had been distinct improvement in the sanitary conditions surrounding the production of milk in four-fifths of the dairies and an elimination of four of the worst dairies, which were not inclined to improve. This elimination was not through any orders

of the Board but because dealers would not purchase milk from dairies which were notoriously bad when they knew that the facts were to be presented to the public.

During May, 1908, a "Tuberculosis Exhibit," under the joint auspices of the New York State Department of Health and the State Charities Aid Association, was held in Geneva. One day was devoted to bovine tuberculosis. Partly as the result of this exhibit milk from two dairies of tuberculin-tested cows was offered to the public. In one case a large dairy company offered the product of a tuberculin-tested herd at 10 cents per quart. This offer met only a limited response. In the other case a small dealer offered milk from tuberculin-tested cows at the current price, six cents per quart. His custom immediately rose to the limit of his supply. Now for the first time in the history of the city it was possible to obtain commercially a milk which a careful parent could consider safe as a food for children.

At the time the score of each dairy for the second quarter of 1908 was furnished to the producer, he was informed that the next scoring of his dairy would probably be given to the public.

Fourth inspection.—The results of the scoring for the third quarter of 1908 may be summarized as follows:

GRADING.	NO. DAIRIES.
Excellent	1
Good	21
Medium	16
Total	38
Average score	449 points
Increase over previous score.....	13 points.

This marked gain is significant in showing the effect of publicity in stimulating the production of clean milk. The most marked instance is that of the dairy which at the preceding inspection had been alone in the "poor" class. His card at the June scoring bore the following: "Mistakes in scoring will be cheerfully corrected. Last quarter your dairy scored next to the lowest. The other man quit because no one would buy his

milk. The arrows indicate where your conditions could be improved." Such radical changes were at once instituted in the conditions for obtaining and handling milk that the score rose from 393 in June to 458 in August and that dairy has remained in the "good" class since that time.

This inspection was also noteworthy in that it marked the appearance of the grade of milk known as "excellent." No bacterial counts were made and therefore it can not be said with certainty that the bacteria in this milk were as few as required by the "inspected" milk standard of New York City, but it is highly probable that it would come within this class. It was milk drawn in clean barns, from reasonably clean, tuberculin-tested cows, by clean milkers, into sanitary pails and promptly cooled.

It should be noted that these marked improvements in the general cleanliness of the dairies were made in the face of unusually adverse financial conditions. The annual contracts of the producers had been made in most cases at three cents per quart. The rise which had occurred in feeding stuffs had reached a point where the food cost alone, with careful feeding, was approximately two cents per quart. This left only one cent per quart for the labor, the interest on the investment and the profit on the business. During the summer and fall of 1908 this region suffered from an unusual drought which produced a marked shrinkage of the milk flow, and a corresponding increase in the cost of production. Under the circumstances any increase in the cost of production due to increased care and labor was made at a distinct financial loss. The fact that these improvements were made in the face of these adverse conditions is the most convincing proof of the power of publicity in this connection.

The proposed publication of the scores of the individual producers brought out a protest, particularly from a few producers who had not taken the earlier statements of the Board seriously and had made no effort to improve their dairy conditions. Originally they had been among the better class of producers and they were chagrined to find that they were now outclassed by their competitors. A public meeting was called and the points of

difference were freely discussed. The opposition of the few who were not prepared for publication was outweighed by the approval of the many who stated that they had striven hard to merit a good score and now the publicity was due them and they demanded it.

As reported to the Board of Health and later given by the press the name of each retailer was accompanied by those of the producers whose product he was handling, the name of each producer being followed by the word "excellent," "good" or "medium." A copy of the score card for each dairy was also placed on file where it was easily accessible to the public. The attention of the public was called to the fact that the milk offered by any retailer was no more desirable than that of his poorest producer, since if he mixed the milk from all of the dairies it would be all reduced to this level, and if he did not mix it some one would get only this poorest milk.

Fifth inspection. The results of the scoring of the dairies for the last quarter of 1908 may be summarized as follows:

GRADING.	No. DAIRIES.
Excellent	1
Good	20
Medium	13
Total	34
Average score	454 points.
Increase over previous score.....	5 points.

This inspection showed a continuation of the gradual improvement which had characterized the whole year.

Summary for 1908.—The practical results of the study for 1908 were as follows:

The grade of some milk had been raised to "excellent," no milk of this character having been included in the former supply. This is comparable with the New York City "inspected" milk — a milk drawn in clean barns, from reasonably clean, tuberculin-tested cows, by clean milkers, into sanitary utensils and promptly cooled.

The grade, "good" milk, which originally included 2 dairies had come to include 20 dairies. They provided a reasonably clean, well cooled, but not, ordinarily, a tuberculin-tested product.

The grade, "medium" milk, which originally included 23 dairies, now included only 13. This represented, in the main, dirty milk.

The grade, "poor" milk, which originally included 15 dairies, had been eliminated. This was essentially filthy milk.

During the year two commercial sources of tuberculin-tested milk had been developed. One of these was the "excellent" dairy above mentioned and the other was one of the best dairies in the "good class."

The general wholesale price of milk was 3 cents and the retail price was 6 cents per quart.

The system of publicity was in full operation and giving general satisfaction to all concerned.

The influence of quality on price had thus far worked only indirectly through the five retailing producers who had obtained more custom from the favorable report on the quality of their product and through the commercial rivalry which their success had provoked.

PROGRESS IN 1909.

Sixth inspection.—The annual contracts between the producers and the retailers practically all dated from April first so that the inspection for the first quarter of 1909 was under conditions quite similar to those at the close of 1908. The results of the inspection for the first quarter of 1909 may be summarized as follows:

GRADING.	NO. DAIRIES.
Excellent	1
Good	22
Medium	7
Total	30
Average score	458 points.
Increase over previous score.....	4 points.

On April 1st the retail milk business underwent marked changes. Nine retailers, including four of those who were producing all or a part of the milk they retailed, formed a dairy company with a central distributing plant. Thus practically all of the milk was retailed by two companies. In connection with this change in management both companies passed the milk through continuous pasteurizers, heating it momentarily to 106–180° F., more frequently at the lower than at the higher temperature. Such pasteurization has little to recommend it from the standpoint of public health.

In making the annual contracts with the producers, the older dairy company includes a clause whereby any producer would receive three cents per quart so long as his dairy scored "medium," three and one-half cents when it scored "good," and four cents when it scored "excellent." The official score of the dairy for each quarter was to be taken as the basis for making settlements. The new dairy company did not have such a clause in its contracts.

Seventh inspection.—The result of the inspection for the second quarter may be summarized as follows:

GRADING.	NO. DAIRIES.
Excellent	3
Good	22
Medium	11
Total	36
Average score	458 points.
Increase from previous score.....	0 points.

This balancing of the score at this inspection with that for the previous quarter was the result of two forces tending in opposite directions.

The dairies whose product was purchased on a sliding scale based on the quality of milk furnished scored as follows:

GRADING.	No. DAIRIES.
Excellent	3
Good	6
Total	9
Average score	474 points.

The dairies furnishing milk to the company which was not paying for milk on the basis of its quality received the following scores:

GRADING.	No. DAIRIES.
Excellent	None.
Good	15
Medium	10
Total	25
Average score	453 points.

The dairies furnishing milk on a sliding scale had made marked improvement, two of them having advanced to the "excellent" class and the remainder all being well up in the "good" class. This improvement resulted from the fact that it was more profitable to produce cleaner milk.

At the same time the score of the dairies which were furnishing their milk at a flat price fell an equal amount. This loss was practically confined to the score of those dairies which had previously retailed their own product. No longer having a financial interest in a record for cleaner milk their conditions of production deteriorated in all cases, one dairy falling from a score of 476 points in March to one of 454 points in June. No experiment could have been devised which would have more clearly brought out the intimate relation between method of payment and quality of product.

Ultimately, the success or failure of the plan of improving a milk supply as here outlined must turn on the extent to which the purchasing public transfers its custom in accord with the official standard of quality. The scorings of the dairies furnish-

ing these two companies were made public early in July. The records of sales, which have been kindly furnished by the companies, shows that during July, August and September the sales of the company with the poorer public record were 73 quarts, 155 quarts and 242 quarts respectively per day less than during June. The loss of trade did not cease here but continued through November, in which month the average sales were 251 quarts per day less than in June.

It is true that there was a distinct decrease in the total consumption of milk in the city during these months, due partly to the considerable number of people absent on vacations and more largely to an increase in the retail price from 6 to 7 cents per quart in July. The records from the competing company, with its dairies all in the "good" and "excellent" classes, shows that its average sales were 106 quarts less per day for July, 61 quarts less per day for August and 94 quarts per day less for September than the June sales. In October they rose practically to the June standard. The sharp decrease in July was probably due to the fact that the public generally held this company responsible for the advance in price. As soon as the 7 cent rate was accepted by the public it proceeded to purchase milk on the basis of quality. While the public purchased less milk on account of its higher price the decrease in business fell almost entirely on the company offering milk of the poorer quality. This sharp and continued falling off in business forced the company which was buying at a flat price to bring pressure to bear on its producers.

Eighth inspection.—The results of this are shown in the scores for the third quarter which were made public September 24, 1909. The summary of the scores was as follows:

GRADING.	NO. DAIRIES.
Excellent	3
Good	29
Medium	3
Total	35
Average score	461 points.
Increase over previous score.....	3 points.

The summary of the dairies selling their product on the sliding scale was as follows:

GRADING.	No. DAIRIES.
Excellent	3
Good	6
Total	9
Average score	473 points.

The summary of the dairies whose product was sold at a flat price was as follows:

GRADING.	No. DAIRIES.
Excellent	None.
Good	22
Medium	3
Total	25
Average	458 points.

From this it is seen that the pressure exerted by the consumers upon the retailer led 7 of the producers to improve sufficiently to get from the "medium" into the "good" class. Notwithstanding the vigorous effort which this company was making to get a better supply of milk their adverse tide of trade did not turn and they continued to lose business during the following three months.

Ninth inspection.—The sanitary conditions of the milk supply improved somewhat during the remainder of the year as shown by the following summary of the scoring for the fourth quarter of 1909:

GRADING.	No. DAIRIES.
Excellent	3
Good	29
Medium	3
Total	35
Average score	466 points.
Increase over previous score.....	5 points.

Of the 9 dairies selling on a sliding scale 3 scored the same as during the preceding quarter and 6 scored higher with a total gain of 90 points. Of the 25 dairies selling to the other company 5 scored the same as before, 3 scored less and 17 scored more with a net gain of 119 points. It is interesting to observe that the single producer who during the preceding quarter retailed his own milk and had been in the "good" class was now selling his milk at a flat price and had lost 5 points, bringing his dairy into the "medium" class.

SUMMARY FOR 1909.

During this year the "excellent" class increased from 1 dairy to 3, the "good" class from 20 dairies to 29 and the "medium" class decreased from 13 to 3 dairies.

The average score of all of the dairies increased from 454 to 466, a gain of 12 points. The score of the poorest dairy was 433 and the next one was 434 at the close of 1908. At the close of 1909 the poorest dairy scored 442 and the next 447. This poorest dairy was the one scoring 434 the preceding year, its competitor for lowest place not finding a purchaser for its product in 1909.

PROGRESS IN 1910.

Tenth inspection.—As has already been noted the annual contracts between the producers and the retailers were made during March and April. Each year one or more of the cleanest producers transferred to Rochester. The summary of the scores for the first quarter was as follows:

GRADING.	No. DAIRIES.
Excellent	3
Good	26
Medium	1
Total	30
Average score	463 points.
Decrease from previous score	3 points.

With the beginning of the new contracts the two large companies purchased milk on the basis of the sanitary conditions under which it was produced, the price being automatically regulated by the official score which the dairy received for that quarter.

Eleventh inspection.—The summary of the scores for the second quarter was as follows:

GRADING.	No. DAIRIES.
Excellent	4
Good	30
Medium	1
Total	35
Average score	463 points.
Increase over previous score.....	0 points.

Twelfth inspection.—The conditions during the third quarter are shown by the following summary of the scores:

GRADING.	No. DAIRIES.
Excellent	4
Good	31
Medium	1
Total	36
Average score	465 points.
Increase over previous score.....	2 points.

Thirteenth inspection.—The conditions at the close of 1910 are shown by the following summary of the scores:

GRADING.	No. DAIRIES.
Excellent	5
Good	29
Medium	5
Total	39
Average score	463 points.
Decrease from previous score.....	2 points.

The decrease in the score at this inspection is mainly due to the advent of three new dairies in the "medium" class.

SUMMARY FOR 1910.

From these summaries it is seen that the average quality of the milk supply remained practically constant during the entire year. Two more dairies were added to the "excellent" class and until the last quarter the "medium" class was represented only by the one dairy which had been at the foot of the list during the preceding year. During the last quarter one of the other dairies dropped back to the "medium" class and three new dairies were added to the supply, all three being in the "medium" class. These latter three dairies are nearly up to the "good" grade and soon made the changes necessary to put them into that class.

PROGRESS IN 1911.

The score cards for the first quarter of 1911 show, for the first time, no milk sold in Geneva from the "poor" or "medium" classes, a condition probably not true of any other city of its size in the United States.

Fourteenth inspection.—The records for the first quarter of 1911 give the following summary of scores:

GRADING.	NO. DAIRIES.
Excellent	5
Good	34
Total	39
Average score	465 points.
Increase over previous score.....	2 points.

TUBERCULIN TEST.

Attention has already been called to the fact that a commercial source of tuberculin-tested milk was provided in 1908 and milk of that quality has been available to the public since that time.

Early in 1910 the milk retailers requested the Board of Health to pass an ordinance forbidding the sale in the city of milk other than that from tuberculin-tested cows.

Since the milk producers are the ones most immediately affected by such an ordinance they were asked to meet with the Board and express their views upon the proposed ordinance. At this meeting all but one of the producers were represented in person or by proxy. The problem of bovine tuberculosis and the part which the State Department of Agriculture was prepared to take both in testing and in indemnifying for reacting animals was presented by Dr. J. F. DeVine of that Department. After the meaning of the proposed ordinance had been made plain each producer was asked to state the number of cows he possessed and his position with regard to the ordinance. The owners of almost exactly 90 per ct. of the 532 cows in the dairies furnishing milk to Geneva expressed themselves as favorable to the ordinance. With a single exception the remaining dairymen stated that they did not favor the ordinance but would cheerfully abide by it if passed. One dairyman, owning approximately 2 per ct. of the cows, stated that he would withdraw from the market if the ordinance was passed.

The largest producer, who strongly favored the ordinance, offered, in case the removal of diseased animals produced a temporary shortage of milk, temporarily to enlarge his herd sufficiently to supply this shortage until his colleagues could replenish their herds. The milk retailers also informed the Board that they would not take advantage of the situation to raise the retail price of milk above 7 cents per quart.

A public meeting for the milk consumers was next called and approximately 100 consumers appeared. After a presentation of the proposed ordinance and its relation to the consumer had been explained by Dr. V. A. Moore, a motion to recommend the adoption of the ordinance was passed with but three dissenting votes.

The objection raised by those dissenting was that the exclusion of the milk from untested cattle would tend to form a monopoly in the milk business and also that the word of the milk retailer was not a sufficient protection against a rise in price.

After further considering the proposed ordinance the Board of Health disposed of the matter by adopting the following:

"This Board having examined the subject of using milk from other than tuberculin-tested cows, and having become satisfied that the use of such milk is attended with danger to the public health, and it having been made to appear to the satisfaction of the Board that there is now in Geneva a considerable supply of milk from tuberculin-tested cows, but not sufficient for all consumers,

"Resolved, That this Board recommend to the public that milk from other than tuberculin-tested cows be not used unless cooked, and especially that such milk be not used for children, and

"Further resolved, That all producers supplying milk to consumers in the city having cows which have not been subjected to the tuberculin test, be urged to have such test made as soon as practicable, to the end that none but tuberculin-tested milk may be furnished to the residents of the city."

Although this proposed ordinance did not receive the sanction of the Board of Health the number of tuberculin-tested cows increased until at the close of 1910 at least 37 per ct. of the cows in the herds furnishing milk to Geneva were tuberculin tested. Unfortunately the conditions were such that the milk from these tuberculin-tested animals was mixed with that from untested herds in all cases except where such milk was offered at an increased price. Under such circumstances the general public did not obtain any benefit except through diluting the milk from diseased animals.

The question of basis for credit for the tuberculin-test presented some difficulties. Where the milk from a tested herd was not retailed as the product of tuberculin-tested animals only one test of the entire herd was required per year. At the time of the other three quarterly examinations no statement to the effect that no untested animals had been added to the herd was required from the dairyman. At the same time it was suggested that he could not afford to add untested animals to a sound herd. It is believed

that more good was actually accomplished by these tactics than would have resulted from more stringent requirements, and that very few untested cows were admitted to tested herds. Where the milk is retailed as the product of tuberculin-tested cows there is no question but that it should be exactly as represented.

The question of what is satisfactory evidence of a proper tuberculin test is also debatable. The statement of a veterinarian might be accepted but this is not always a satisfactory arrangement. One dairyman furnished the statement from a veterinarian that he had "examined the herd of ———— (using tuberculin test) and found them free from tuberculosis." A request for the records of the test brought a statement showing that the temperatures had been taken at 7 and at 9 the day before, and at 6 and at 9 the day after, not stating whether the observations were made in the forenoon or the afternoon nor that any tuberculin had been used. As the product of this herd was not being retailed as tuberculin-tested milk the interested parties were informed that inasmuch as the dairyman had paid his money for the test in good faith he would be given credit for it, but that in future no such testing would be tolerated. Some months later a retest of this herd by a competent veterinarian gave five reacting animals.

The procedure as adopted was to give credit for a tuberculin test only after receiving the detailed records of such test signed by the veterinarian, with a sworn statement by the dairyman that the test included his entire herd. A sworn statement by the veterinarian was not considered necessary after the passage of the State law making any irregularity on his part punishable by the loss of his right to practice in the State. The incident above given occurred before the passage of this law. Since, under the present law, the records of the tuberculin tests are filed with the State Department of Agriculture an approval of the test by that Department was accepted in lieu of the detailed records.

GRAPHICAL REPRESENTATION.

The variations in the quality of the milk supplied during the three years covered by this study are clearly brought out in Chart I. It will be noted that the "poor" milk disappeared after the second inspection in 1908 and has not reappeared in the market supply.

The supply of "medium" milk also finally disappeared. Its slight apparent increase at the second inspection in 1908 was due to the withdrawal of two of the dairies in the "good" class, as explained on page 49. The striking decrease in "medium" milk shown at the third inspection of this year was coincident with the publication of the scores of the producers as explained on page 52. The increase in the amount of "medium" milk as shown at the second inspection of 1909 immediately followed the retirement of retailers who had been selling their own product as noted on page 55. The rise in the amount of "medium" milk at the close of 1910 was mainly due to the entrance of three new dairies as explained on page 59. By the date of the final inspection business competition had brought all of the dairies into the "good" class.

Attention should be called again to the fact that in the previous summaries and in this chart the dairy has been used as the basis of computation. It would have been preferable to use the number of cows rather than the number of dairies in this connection. While the number of cows in each dairy was noted at some of the inspections this data was often omitted.

While this chart shows truly remarkable improvement it actually falls short of the truth. This is due to the fact that each dairy was given equal weight for the reason given above. The largest dairies were the ones in which improvement was most marked; thus the chart indicates that at the close of 1910 about 12.8 per ct. of the supply came from dairies in the "excellent" class, while 37 per ct. of the cows were in these 5 dairies.

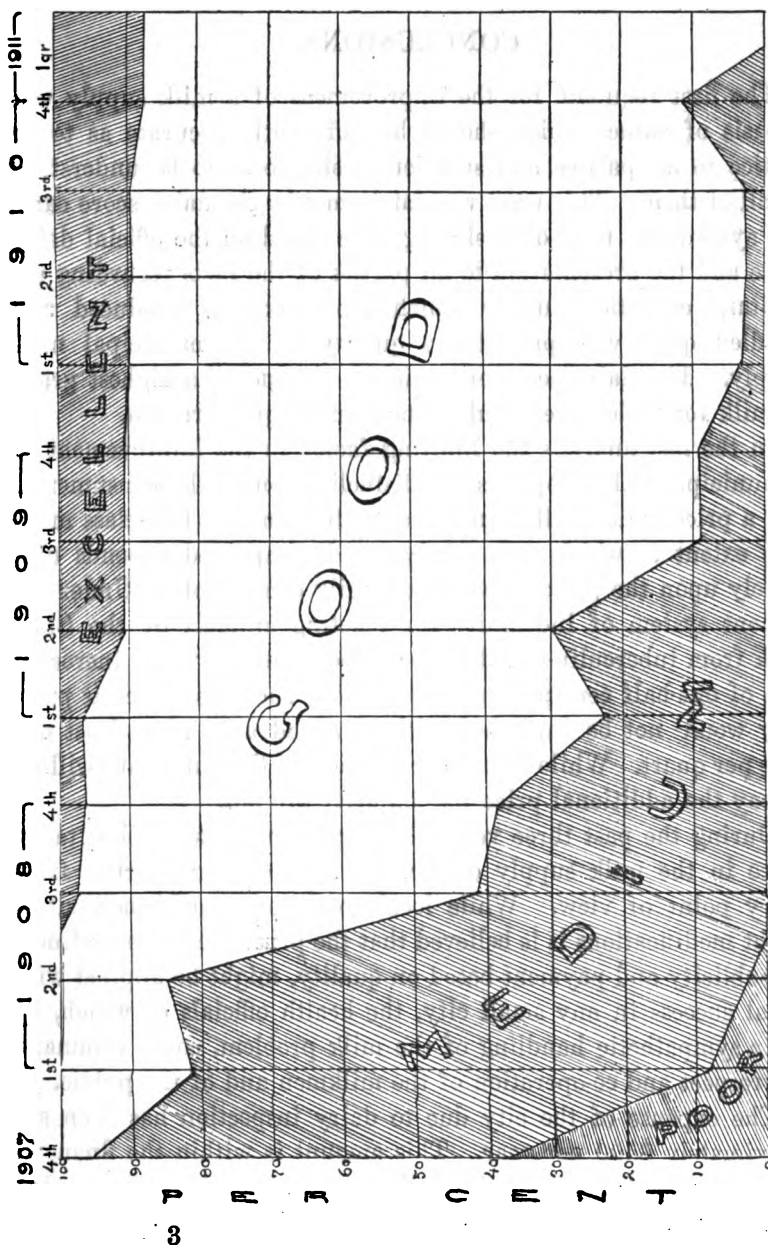


CHART I.—IMPROVEMENT IN SANITARY CHARACTER OF MILK SUPPLY OF CITY OF GENEVA, THROUGH PUBLICITY AND PAYMENT BASED ON QUALITY.

CONCLUSIONS.

The first requisite for the improvement of a milk supply was a basis of values which should be sufficiently accurate as to do justice to all parties and sufficiently simple as to be understood by all of them. This want was fairly met by the dairy score card.

Payment for milk on a sliding scale based on the official dairy score and the presentation to all parties of the facts regarding the sanitary conditions under which the milk was produced and handled quickly improved the quality of the municipal milk supply. The dairymen were quick to produce the highest grade of milk for which they could obtain an adequate return.

In the last analysis the limiting factor in the improvement of a municipal milk supply is the disinclination of the consumer to pay a price which will permit the production of a first-class milk. The extent to which any supply can be improved depends ultimately upon the price at which the milk can be sold. Under the present system of indemnity for reacting animals by the State milk from tuberculin-tested cows can be furnished at an increased cost of one-half cent per quart. Without such assistance it probably would not be furnished without an advance of at least one cent per quart. While a small proportion of the public are willing to pay the additional price the majority are not.

During the past three years the improvement which has taken place in the milk supply of Geneva has been noteworthy from every point of view. While local conditions would necessitate slight modifications it is believed that the principles here outlined, of publicity and payment based on quality, might be applied with equal success in any small city, the health officials of which, by their sympathetic handling of the milk problem, could command the respect and co-operation of the milkmen and of the public.

The expense of the city due to dairy inspection has been approximately \$500 per year. This amount is within the financial reach of practically all cities and cannot be considered a burden in view of the results obtained.

REPORT
OF THE
Botanical Department.

F. C. STEWART, *Botanist.*
J. G. GROSSENBACHER, *Associate Botanist.*
G. T. FRENCH, *Assistant Botanist.*
F. A. SIRRINE, *Special Agent.*

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[67]

REPORT OF THE BOTANICAL DEPARTMENT.

SEED TESTS MADE AT THE STATION DURING 1910.*

G. T. FRENCH.

SUMMARY.

Farmers and others may send samples of agricultural seeds to the Station and have them tested for purity free of charge; but the Station does not make germination tests. During 1910, 947 samples were tested — 566 of alfalfa, 200 of red clover, 69 of alsike clover, 13 of white clover, 77 of timothy and 22 of miscellaneous seeds. Many of the samples received were too small for a dependable analysis. The percentage of samples infested with dodder (11.13 per ct. for alfalfa and 3.5 per ct. for red clover) is considerably smaller than that found in previous years. This indicates that seedsmen are now more careful about dodder than they were formerly. The alfalfa samples show a marked increase in the number containing large-seeded dodder. In more than half of the infested samples the dodder was of the large-seeded kind which can not be separated by sifting. The frequent occurrence of the seed of *Centaurea repens* in the alfalfa samples shows that much of our seed is imported from Asia Minor. This is known as Turkestan alfalfa. Only 4 samples (3 of alfalfa and 1 of alsike clover) were found to be adulterated. It appears that red clover seed sold in the State during 1910 was of higher average quality than usual. As regards purity and general appearance, the timothy seed, also, was of high grade. Russian thistle seed is a frequent impurity of alfalfa seed, but the experience of farmers indicates that the weed is rarely able to maintain itself in New York and is not to be feared. Roquette, a foreign, mustard-like plant, has appeared in some alfalfa fields in the State having been introduced with imported alfalfa seed. Little is known of its capabilities as a troublesome weed.

*A reprint of Bulletin No. 333. February, 1911.

INTRODUCTION.

During the past five or six years farmers and seed dealers throughout the State have been sending to the Station samples of agricultural seeds to be tested for purity. Such tests are made willingly and without expense to the sender; but the number of samples received is now so large that the Station is unable to make complete quantitative analyses such as would enable us to report the exact percentage of each kind of impurity present as is done by several seed laboratories of the country. However, it is our aim to give such information concerning noxious weeds, adulterants and general appearance as will enable the purchaser to grade and judge the sample fairly. This seems to be all that is necessary for most practical purposes, although a complete test is sometimes requested and could, perhaps, be used to advantage.

Most of the samples are received during the purchasing season, that is, between February 1st and June 1st; but some are received at intervals throughout the whole year. Since most senders of samples wish a report at once, analyses are made as promptly as possible. Usually, a report can be mailed the same day the sample is received. However, it is advisable to commence looking for seed early so that there may be plenty of time for having tests made. Sometimes it is necessary to test several lots of seed before one is found which is fit to sow.

During the year 1910, 947 samples of seed were received and tested for purity. Of these, 566 were alfalfa, 200 red clover, 69 alsike clover, 13 white clover, 77 timothy and 22 miscellaneous. Samples received prior to June 5th were tested by Mr. S. M. McMurran; those received after this date, by the writer.

METHODS OF MAKING TESTS AND REPORTING RESULTS.

Each sample received is examined very thoroughly. In the case of alfalfa and red clover the sample is first carefully sifted in a 20-mesh sieve in order to separate as many foreign seeds as possible, especially dodder. If dodder is found the number of seeds per pound is computed. Also, the size of the dodder seed (whether of the large or small-seeded kind) is noted,

and if it is too large to pass through the 20-mesh sieve recommended for removing dodder from alfalfa¹ special mention is made of the fact. Usually, if a sample appears to contain more than about one per ct. of any one kind of foreign seed the exact percentage is determined. However, a sample is not reported as adulterated unless it contains five per ct. or more of some one kind of foreign seed or inert matter. When weed seeds are found their presence is always reported, the amount being indicated by the use of such phrases as, "present in considerable quantity," "quite a little," "present in traces," etc. If inert matter such as dirt or chaff is present in considerable quantity it is so stated in the report. Also, if the seed appears to be old, or if many shriveled or dead seeds are present a statement to that effect is made. In short, our report furnishes the purchaser the information necessary for judging fairly well the quality of the seed. Certainly, it enables him to avoid adulterated samples and those containing seeds of dodder or other noxious weeds.

GERMINATION TESTS.

In many cases germination tests are necessary to determine what percentage of the seed will grow. Some kinds of seeds, if not harvested and stored properly, soon lose their ability to germinate. Then too, the mixing of old seed with new is sometimes practiced so that the only safe and reliable way to learn the viability of a given lot of seed is to make a germination test. Frequently, the Station receives samples of seed with the request that they be tested for germination. While we realize the importance of germination tests it seems necessary to refuse such requests. At present, the Station has not the facilities for making large numbers of germination tests. Besides, the Station should not do for farmers what they can so easily do for themselves.²

SUGGESTIONS CONCERNING SEED SAMPLES.

Those who are to have seed tested must be warned that a fair analysis cannot be made from a small sample. In order to make a dependable analysis a considerable amount of seed is necessary.

¹ Circular No. 8 of this Station.

² Directions for making germination tests of seeds at home are given in Leaflet M of this Station.

It is self-evident that as the weight of the sample decreases so must its chance of being a fair representative of the lot of seed from which it was taken. Attention is called to this point because more than half of the samples received during 1910 were below the required weight, and 163, or 17 per ct., were altogether too small for a dependable analysis. We strongly urge that for the several kinds of seed the following quantities be sent for purity tests:

Alfalfa and clovers..... 2 ounces
Grass seeds, millet and the smaller vegetable seeds... 1 "

The samples should be as representative of the seed in bulk as is practicable. For instance, in sampling a bag care should be taken to obtain seed from the top, middle and bottom. A sample taken wholly from the top of the bag may be very misleading.

STANDARDS OF PURITY AND GERMINATION.

The United States Department of Agriculture has published a table³ showing the percentage of purity and viability of high-grade seed of different kinds and recommends that these percentages be adopted as standards. This table is here reproduced (in part) as a guide to purchasers.

TABLE I.—PURITY AND VIABILITY OF HIGH GRADE SEEDS.

SEED	Purity	Viability	SEED	Purity	Viability
	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>	<i>Per ct.</i>
Alfalfa.....	98	85-90	Clover, white.....	95	75-90
Barley.....	99	90-95	Corn, field.....	99	90-95
Beans.....	99	90-95	Corn, sweet.....	99	85-90
Beet.....	99	150	Fescue, meadow.....	95	85-90
Blue grass.....	90	45-50	Millet.....	99	85-90
Buckwheat.....	99	90-95	Oats.....	99	90-95
Cabbage.....	99	90-95	Onion.....	99	80-85
Celery.....	98	60-65	Peas.....	99	93-98
Clover, alsike.....	95	75-80	Timothy.....	98	85-90
Clover, crimson.....	98	85-90	Tomato.....	98	85-90
Clover, red.....	98	85-90	Wheat.....	90	90-95

³ U. S. Dept. Agr. Yearbook. 1896:624.

RESULTS OF ALFALFA SEED TESTS.

During the past year 566 samples of alfalfa seed have been tested for purity. Of 368 samples which were graded according to color and general appearance, 229 were marked "excellent," 115 "average," and only 24 "poor." Of samples considered practically pure, there were 43. In general, these samples seem to be of a higher grade than the 548 samples tested between November 20, 1906, and August 15, 1908. Fewer samples contained dodder, and there was less evidence of adulteration. That much imported seed is still on the market in the State seems probable from the fact that 89 samples contained *Centaurea repens*. The presence of seed of this weed is considered strong evidence that alfalfa which contains it was grown in Asia Minor. *Centaurea repens*, which is a native of Asia Minor, when grown under natural conditions in this country, has never been known to produce seed.

DODDER SEEDS IN ALFALFA SEED.

The dodder found in 35 of the 63 samples which contained it was of the large-seeded species and would not go through our 20-mesh sieve. It appears, therefore, that the large-seeded species was more common than during 1906-1908, for during that period only 14 of the 126 dodder-infested samples contained the large kind. Also, since 112 of the 548 alfalfa samples tested during 1906-1908 contained the small-seeded dodder, and only 28 of the 566 samples tested in 1910 contained this kind, one might infer that the alfalfa seed on the market during 1910 was more thoroughly sifted than that sold in the previous years. Seed containing the large dodder should be avoided, since little or no dependence can be placed upon its removal by ordinary methods of sifting.

TABLE II.—DODDER IN ALFALFA SEED SAMPLES ANALYZED IN 1910

SAMPLE NUMBER	Number of seeds per lb.	Size of seed		SAMPLE NUMBER	Number of seeds per lb.	Size of seed	
		Large	Small			Large	Small
566.....	1	.....	X	282.....	32	.....	X
599.....	2	.....	X	118.....	34	.....	X
154.....	3	X	.....	16.....	36	.....	X
468.....	5	X	.....	99.....	36	X	.....
365.....	6	X	.....	229.....	36	.....	X
430.....	6	X	.....	421.....	36	X	.....
456.....	6	X	.....	231.....	40	X	.....
447.....	7	.....	X	300.....	41	X	.....
175.....	8	X	.....	520.....	46	X	.....
178.....	8	X	.....	409.....	48	.....	X
209.....	8	.....	X	506.....	48	.....	X
342.....	10	X	.....	310.....	50	X	.....
346.....	10	X	.....	477.....	54	.....	X
377.....	10	.....	X	519.....	57	X	.....
207.....	11	.....	X	424.....	58	X	.....
482.....	11	X	.....	451.....	62	X	.....
147.....	12	.....	X	264.....	64	.....	X
294.....	12	.....	X	406.....	66	X	.....
380a.....	14	.....	X	562.....	68	X	.....
379.....	15	.....	X	126.....	70	X	.....
216.....	16	X	.....	440.....	79	.....	X
278.....	16	.....	X	533a.....	102	X	.....
297.....	16	X	.....	446.....	108	.....	X
163.....	20	.....	X	513.....	145	.....	X
13.....	22	X	.....	31.....	156	X	.....
180.....	22	X	.....	510.....	161	X	.....
369.....	22	X	.....	448.....	240	.....	X
430.....	25	.....	X	487.....	374	.....	X
417.....	25	.....	X	362.....	451	X	.....
170.....	26	X	.....	511.....	453	.....	X
223.....	26	X	.....				
456.....	28	X	.....	Total (63) ..	.....	35	28
527.....	31	X	.....				

ADULTERATED SAMPLES.

Only *three* alfalfa samples were found to be adulterated. One of these contained 35 per ct. yellow trefoil (*Medicago lupulina*), while the other two were adulterated with 6 per ct. of sweet clover (*Melilotus* sp.). During 1906–1908 ten samples showed evidence of adulteration, that is, they contained 5 per ct. or more of sweet clover or yellow trefoil. Over 1 per ct. of yellow trefoil or sweet clover was present in eleven of the 1910

samples. Nine of these contained sweet clover and two yellow trefoil.

TABLE III.—ALFALFA SAMPLES WHICH CONTAINED AT LEAST 1 PER CT. SWEET CLOVER OR YELLOW TREFOIL

Lab. number	ADULTERANT		Lab. number	ADULTERANT	
	Kind	Per ct.		Kind	Per ct.
466	Sweet clover.....	2-3	35	Yellow trefoil.....	35
477	Sweet clover.....	3	417	Sweet clover.....	6
485	Sweet clover.....	2	440	Sweet clover.....	6
490	Sweet clover.....	2	447	Sweet clover.....	2
497	Sweet clover.....	2	457	Sweet clover.....	2
522	Yellow trefoil.....	1			

It is probable that with the exception of the three adulterated samples the sweet clover and yellow trefoil seed found came from plants that were growing in the alfalfa fields at harvest time, and that no willful mixing was intended.

One sample of alfalfa was received which contained 50 per ct. of flax seed. Just how this occurred we do not know. Certainly, flax seed looks so little like alfalfa seed that one would hardly think of using it as an adulterant.

Judging from these samples it seems quite probable that in New York State the adulteration of alfalfa is much less common than in previous years.

NOXIOUS WEEDS.

Our analyses show that English plantain (*Plantago lanceolata*), chicory (*Cichorium intybus*) and curled dock (*Rumex crispus*) are the noxious weeds which occur most commonly in alfalfa seed. Wild carrot (*Daucus carota*) and charlock (*Brassica arvensis*) were found in only a few samples. In the 566 samples examined, English plantain was present in 187, chicory in 116, dock in 110, charlock in 31, and wild carrot in 14. In 14 samples, English plantain was reported in considerable quantities, but in the other 173 it occurred only in traces. In one of the chicory-infested samples there was considerable of the weed, but in the remaining 115 it was present only in traces. No

samples contained dock, wild carrot or charlock in considerable quantities.

OTHER WEEDS AND IMPURITIES.

As previously stated, 89 of the samples examined contained seeds of *Centaurea repens* and were considered to be samples from seed that had been grown in Turkestan. This Turkestan variety has been known to succeed in New York State, but it is best to obtain American grown seed when possible. Eight other samples, though not containing seeds of *Centaurea repens*, were thought to have been imported from Turkestan because of the dull, grey and dusty color which seems to be characteristic of this variety.

Seeds of green foxtail (*Setaria viridis*), lamb's quarters (*Chenopodium album*) and pigweed (*Amaranthus* spp.) were found in many samples. Green foxtail occurred in considerable quantity in 8 samples, Russian thistle in 7, and lamb's quarters in 1. Other samples contained these weed seeds in traces only. Following is a list of the more common weeds found and the number of samples which contained them:

	occurred in	340 samples.
Green foxtail (<i>Setaria viridis</i>).....	"	231
Lamb's quarters (<i>Chenopodium album</i>).....	"	111
Pigweed (<i>Amaranthus</i> spp.).....	"	94
Russian thistle (<i>Salsola Kali</i> var. <i>tenatifolia</i>).....	"	90
Yellow foxtail (<i>Setaria glauca</i>).....	"	89
<i>Centaurea repens</i>	"	33
Timothy (<i>Phleum pratense</i>).....	"	24
Alsike clover (<i>Trifolium hybridum</i>).....	"	22
Catchfly (<i>Silene</i> spp.).....	"	16
Sheep sorrel (<i>Rumex acetosella</i>).....	"	14
Melilot (<i>Melilotus</i> spp.).....	"	7
Crab grass (<i>Digitaria sanguinalis</i>).....	"	2
Roquette (<i>Eruca sativa</i>).....	"	

RESULTS OF RED CLOVER SEED TESTS.

Red clover seed is notorious for its impurity. It frequently contains dodder and many other kinds of foreign seeds, much small, low-grade clover seed, and is sometimes adulterated with seeds of yellow trefoil. In this State, analyses made prior to 1910 indicate that it is more likely to be of low grade than is alfalfa seed. Accordingly, it is encouraging to note that analyses made at the Station during the past year show that red clover seed sold in the State during 1910 was, on the average, much purer and of higher grade than usual. In grading the 200 red

clover samples according to color and general appearance, 165 were marked "excellent," 30 "average," and only 5 "poor." Although only 48 of these were pure samples, the others (with five exceptions) contained foreign seeds only in traces. Of the 5 excepted samples, 2 contained considerable English plantain, 2 considerable timothy, and one considerable alsike clover. Fully half of the 200 clover samples weighed less than two ounces (the smallest amount that should be used for a purity test) and, of these, 43 were *much* too small for a dependable analysis. No case of adulteration was found.

DODDER AND OTHER FOREIGN SEEDS.

Dodder was found in seven samples at the rate of 15, 15, 22, 36, 56, 824 and 1,159 seeds per pound. In every case it was of the large-seeded kind. Other kinds of weed seeds found and the number of samples containing them were as follows:

English plantain (<i>Plantago lanceolata</i>)	occurred in	96 samples
Dock (<i>Rumex</i> spp.)	"	94
Wild carrot (<i>Daucus carota</i>)	"	3
Canada thistle (<i>Cirsium arvense</i>)	"	2
Chicory (<i>Cichorium intybus</i>)	"	2
Green foxtail (<i>Setaria viridis</i>)	"	107
Lady's thumb (<i>Polygonum persicaria</i>)	"	52
Sheep sorrel (<i>Rumex acetosella</i>)	"	51
Yellow foxtail (<i>Setaria glauca</i>)	"	35
Timothy (<i>Phleum pratense</i>)	"	35
Lamb's quarters (<i>Chenopodium album</i>)	"	18
Pigweed (<i>Amaranthus</i> spp.)	"	17
Alsike clover (<i>Trifolium hybridum</i>)	"	11
Catchfly (<i>Silene</i> spp.)	"	8

RESULTS OF ALSIKE CLOVER SEED TESTS.

The 69 samples of alsike clover seed received show that this kind of seed sold in the State during 1910 was, on the whole, of average grade. Six samples were pure. Only 1 sample was adulterated (with yellow trefoil), and none contained dodder. Besides the adulterated sample, yellow trefoil was found in 4 others, 1 of which contained 2 per ct. trefoil and the other 3 only traces. Timothy, sheep sorrel, dock, catchfly and English plantain were the foreign seeds most often found. Graded on the basis of color and general appearance, 52 samples were marked "excellent," 16 "average," and 1 "poor." Six samples were altogether too small for a dependable analysis, and many others weighed less than two ounces, the quantity which should

be sent. Below is a list of the common impurities found and the number of samples in which each was present:

Dock (<i>Rumex</i> spp.)	occurred in	22 samples.
English plantain (<i>Plantago lanceolata</i>)	"	9 "
Ox-eye daisy (<i>Chrysanthemum leucanthemum</i>)	"	5 "
Canada thistle (<i>Cirsium arvense</i>)	"	1 "
Timothy (<i>Phleum pratense</i>)	"	61 "
Sheep sorrel (<i>Rumex acetosella</i>)	"	38 "

RESULTS OF TIMOTHY SEED TESTS.

Timothy seed samples examined during 1910 were very free from impurities, but since the vitality of timothy seed in storage decreases more rapidly than that of many other agricultural seeds we take this opportunity to urge that buyers make a practice of determining the percentage of germination for each lot of timothy before purchasing.

On the basis of color and general appearance, seventy-four samples were marked "excellent," three "average" and none "poor." Fifty-seven were practically pure, but four were altogether too small for a reliable test. Following is a list of the impurities found and the number of samples in which each occurred:

Dock (<i>Rumex</i> spp.)	occurred in	2 samples.
English plantain (<i>Plantago lanceolata</i>)	"	2 "
Alsike clover (<i>Trifolium hybridum</i>)	"	35 "
Sheep sorrel (<i>Rumex</i> spp.)	"	8 "
Pigweed (<i>Amaranthus</i> spp.)	"	7 "
Green foxtail (<i>Setaria viridis</i>)	"	7 "
Lamb's quarters (<i>Chenopodium album</i>)	"	4 "
Broad plantain (<i>Plantago</i> spp.)	"	3 "
Lady's thumb (<i>Polygonum persicaria</i>)	"	1 "
Sweet clover (<i>Melilotus</i> spp.)	"	2 "

MISCELLANEOUS SAMPLES TESTED.

The miscellaneous samples sent in for analysis included the following:

White clover	13 samples.	Rape	1 sample.
Red top	5 "	Millet	1 "
Kentucky blue grass	6 "	Lawn grass	1 "
Meadow fescue	1 "	Oats	1 "
Orchard grass	1 "	Beardless barley	1 "
Vetch	2 "	Onion	1 "
Crimson clover	1 "		

Though cases of adulteration of Kentucky blue grass, orchard grass, meadow fescue and red top have been reported by several seed laboratories, no evidence of adulteration was found in the few samples of these seeds examined in this laboratory during 1910.

ROQUETTE.

Eruca sativa.

Several times during the past year our attention has been called to the occurrence of roquette in alfalfa fields. In one case a farmer brought in specimens of the weed for identification and seed for examination, saying that his alfalfa field was full of it and that he was convinced that it had been introduced along with the alfalfa seed used, for several other fields sown with this lot of seed also produced a crop of the same weed. Upon testing one pound of the alfalfa seed, ten seeds of roquette were found.

It seems that the seed was purchased with the understanding that it had been tested at this Station and reported free from seeds of noxious weeds. The farmer, therefore, felt that he should get what he had paid for and since he was very desirous of avoiding the introduction of noxious weeds this experience was discouraging to say the least.

Roquette is new to this State and until the past year its seeds have either been absent from samples of alfalfa examined or else overlooked. During the year, Mr. F. H. Hillman of the Department of Agriculture at Washington kindly identified some of the seeds for us and since then their occurrence has been reported.

Roquette belongs to the mustard family, is a rank-growing plant sometimes two feet in height, has light yellow flowers with purple veins, and flat-beaked pods two-thirds of an inch long. It is, therefore, a striking weed in alfalfa fields and at once leads one to believe that it may be a troublesome one. Though our observations are of too short duration for a definite statement of what its nature will be in this State it seems likely that very little trouble from it will be experienced. Reports from Oklahoma⁴ and Kansas state that it is an annual and indicate that where it is winter killed farmers need not worry over its occurrence. In Europe roquette is sometimes grown as a salad plant.⁵

RUSSIAN THISTLE.

(Salsola Kali var. tenuifolia.)

Russian thistle, which has been considered a bad weed in the West, is frequently sown in this State with alfalfa seed. Natur-

⁴ Okla. Sta. Bul. 83:17.

⁵ Bailey, L. H. Cyclopaedia of American Horticulture, p. 1546.

ally, considerable fear has been expressed concerning its outcome here and many inquiries have come to the Station. From reports sent in to us recently by W. J. Wilkie of Geneva, John Crowe of Dundee, A. H. Coonradt of Morristown, C. W. Stanton of Cohocton and O. F. Ross of Lowville, who have had an opportunity to observe the progress of this weed for two seasons at least, it seems safe to conclude that little or no fear need be felt concerning it as a troublesome weed in alfalfa fields of this State. Under some conditions it will appear every year here, for it has been found growing abundantly around the works of the Solvay Process Company at Syracuse for several years. Mr. C. W. Stanton of Cohocton reports that a few plants appeared in one of his alfalfa fields the second year and grew to be sixteen or eighteen inches high. These plants, when noticed by him during 1909 and 1910, were destroyed and he does not expect any further trouble from them. In no case did the thistle appear outside of the alfalfa field. The other four men report that nothing was seen of the weed after the first season.*

BULLETINS ON SEEDS AND WEEDS.

For further information concerning seed testing, impurities in agricultural seeds, weeds, and adulteration of forage plant seeds, the reader is referred to the following publications:

- Beal, W. J. Seeds of Michigan weeds. Mich. Sta. Bul. 200. 1910. East Lansing, Mich.
- Brown, E. and Hillman, F. H. Seed of red clover and its impurities. U. S. Dept. Agr. Farmers' Bul. 260. 1906. Washington, D. C.
- Hillman, F. H. Dodder in relation to farm seeds. U. S. Dept. Agr. Farmers' Bul. 306. 1907. Washington, D. C.
- The adulteration of forage plant seeds. U. S. Dept. Agr. Farmers' Bul. 382. 1909. Washington, D. C.
- Roberts, H. F. and Freeman, G. F. Commercial seeds of brome-grass, and of English and Kentucky blue grasses: Adulterants and substitutes and their detection. Kan. Sta. Bul. 141. 1907. Manhattan, Kans.
- Selby, A. D. A second Ohio weed manual. Ohio Sta. Bul. 175. 1906. Wooster, O.

* The Station desires information concerning the occurrence of troublesome new weeds which appear to have been introduced into the State by means of impure seed; also, specimens of such weeds are desired.

SPRAYING TO ERADICATE DANDELIONS FROM LAWNS.*

G. T. FRENCH.

SUMMARY.

An experiment made at this Station during the past two years indicates that the spraying of lawns with a solution of iron sulphate for the purpose of eradicating dandelions is unlikely to be successful in New York. In 1909, a strip of lawn on the Station grounds was sprayed six times between April 23 and September 24 with a solution containing 1.5 lbs. iron sulphate in each gallon of water. In 1910, the same strip was again sprayed six times between April 15 and June 29, using two pounds of iron sulphate per gallon. In both seasons the blooming of the dandelions was almost wholly prevented and many of the plants were killed outright by the treatment. Yet, on an area of 1,000 sq. ft. there were 1,085 live dandelions in July, 1910, when the treatment had to be discontinued because of the danger of ruining the lawn. After each application (with one exception) the sprayed area was black and unsightly for several days. Apparently, the treatment did not materially injure the grass during the first season; but in the second season, with more frequent applications of a stronger solution, the grass was considerably injured.

The failure of the treatment seemed to be due to the great vitality of the dandelion roots. In one of our experiments a plant was cut off below the crown seven times and another one eight times before they were finally killed. Why spraying should succeed in some parts of the United States and fail in New York is not clear. At present, no method of spraying lawns to kill dandelions can be recommended for use in New York.

*A reprint of Bulletin No. 335. March, 1911.

INTRODUCTION.

In New York, the dandelion is a very common and persistent weed in lawns, and a practicable method of eradicating it is much sought. Recent experiments in North Dakota,¹ Rhode Island,² Iowa,³ Ohio⁴ and Colorado⁵ have led to the recommendation of the use of iron sulphate (copperas) applied in the form of a fine spray. For North Dakota, Prof. Bolley recommends spraying the lawn, at intervals of four to six weeks throughout the season, with a solution containing one and one-half to two pounds of iron sulphate in each gallon of water. In order to determine the value of this treatment when applied under New York conditions the following experiment was made:

OUTLINE OF THE EXPERIMENT.

In the spring of 1909 a plat 100 feet long by ten feet wide was marked off in a five-year-old lawn on the Station grounds. On this area, dandelions of two species, *Taraxacum officinale* and *T. erythrospermum*, were plentiful. The grass consisted chiefly of Kentucky blue grass, *Poa pratensis*. The soil was clay loam. During 1910 this plat was sprayed six times on the following dates: April 23, May 11, June 14, July 23, August 27 and September 24. The solution used for spraying consisted of 1.5 pounds of iron sulphate dissolved in one gallon of water. It was applied in the form of a fine spray at the rate of 50 to 65 gallons per acre by means of a knapsack sprayer. An attempt was made

¹ N. Dak. Sta. Bul. 80: 565-567. March, 1908. N. Dak. Sta. Press Bul. 26. Oct. 1907 (re-edited July, 1908).

² Rhode Island Sta. Bul. 133: 55-56. April, 1909.

³ Iowa Sta. Bul. 105: 289-290. July, 1909.

⁴ Ohio Sta. Cir. 102:5. May, 1910.

⁵ Letter from B. O. Longyear, Colorado Expt. Station, April 6, 1910.

In this letter Prof. Longyear states that he has had success by using a 15 per ct. solution of iron sulphate (1¼ lbs. per gallon), in water and applied in the form of a fine, forcible spray with a bucket spray pump. Three applications, beginning about the first of August and made three weeks apart entirely cleared the experimental plats of all dandelions.

to spray on sunshiny days two or three days after cutting and to avoid mowing sooner than two or three days after spraying, as directed by Prof. Bolley.

The following spring a majority of the dandelion plants were still alive and, apparently, vigorous. Accordingly, for the season of 1910, it was decided to use a stronger solution, viz., one containing two pounds of iron sulphate in each gallon of water, and to spray more frequently. Six applications were made between April 15 and June 29 at intervals of 11 to 18 days.

DETAILS OF THE EXPERIMENT IN 1909.

FIRST SPRAYING.

The first spraying was made on the afternoon of April 23 previous to the first mowing of the season. Considerable foliage of both dandelions and grass had already been produced but there were no blossoms. There was no rain of importance until April 27, four days after the spraying. On the second day following the treatment the sprayed plat presented a black, unsightly appearance. Not only were the dandelion leaves blackened, but also the tips of the grass leaves. The discoloration was more persistent this time than after most of the other sprayings. It did not entirely disappear until the 10th of May, seventeen days after the spraying. This application was not as effective as most later ones, still a large part of the foliage of each plant died and many grass leaves were killed. Just why this spraying was not more effective is not clear, but it was probably due in part to the thick foliage, which prevented the lower leaves of some plants from being thoroughly covered with the spray. The weather was cold until the first week in May so that neither grass nor dandelions made much growth. Before the second spraying, however, considerable foliage had been formed again and though the plants outside of the sprayed plat were larger, those in the treated area were rapidly regaining their normal condition.

SECOND SPRAYING.

The second spraying was made on May 11, eighteen days after the first. The dandelions had made so much growth that it appeared as though a treatment at this time would be more effective than later. The day following the treatment the leaves were covered with small, whitish spots and were somewhat withered but very few had turned dark. On the 13th, the area, as a whole, looked quite dark, but on close inspection some portion of the leaves on nearly all of the plants was green. On the 14th, however, the plants were quite black and the greater part of the foliage was dead. At this time, a few large plants and most of the flower buds appeared to be but little injured. Nevertheless, fewer than a dozen of these buds developed on the entire plat, while the plants on the adjoining lawn were full of blooms. There is no doubt that spraying at this time prevented blooming, but it did not seem to lessen the ability of the roots to send out new leaves. The sprayed area never assumed the black appearance which followed the first spraying. The weather being warm, a rapid growth of grass and dandelions took place, and by May 17, only four days after spraying, the plat was again fresh and green.

THIRD SPRAYING.

This application was made on June 14, four weeks after the second. The lawn was mowed on the 12th and no rain fell until the 18th. The dandelions were nearly all killed to the ground, but a few leaves, spotted with green, remained alive. On the 18th new leaves were showing and on the 23d of July, the date of the fourth spraying, the dandelions were thrifty and green but the plat was noticeably brown. The soil was quite dry at this time and the grass had grown but little. The dark color gradually shaded into brown and green but the greenish-brown color of the sprayed area was quite noticeable at the time of the fourth spraying.

FOURTH SPRAYING.

On July 23 the plat was sprayed for the fourth time. A heavy rain occurred during the following night, and though the dark

color followed, the dandelions always showed considerable green foliage. The plat was not sprayed until 5 P. M., and it is probable that the heavy rain washed off the material before it had time to react fully. After this spraying the dandelions recovered rapidly but the grass continued yellow. The adjacent lawn was also in a dried condition, and this seemed to indicate that drought, rather than spraying, was the main cause of the yellow color of the grass blades. The sprayed plat continued quite dark up to the 27th of August, the date of the fifth spraying, but there was no apparent difference in the vigor of the dandelions in the sprayed and unsprayed lawns.

FIFTH SPRAYING.

The fifth spraying was made on the 27th of August; it resulted in killing most of the dandelion tops and in blackening the entire area. The drought continued until after the sixth spraying so that the grass remained in a dried condition and the dark color persisted. On the 20th of September the dandelions had formed large tops again and a few seeds, but many more seeds were produced on the unsprayed lawn.

SIXTH SPRAYING

This spraying, the last of the season, was made on September 24. It killed practically all of the dandelion tops, though the lower leaves of a few large plants remained green; the others turned black but gradually recovered as in previous sprayings. Most of the plants went into the winter with some foliage.

DETAILS OF THE EXPERIMENT IN 1910.

It was apparent on April 15, 1910, previous to making the first application of the season, that the past year's spraying had not resulted in killing nor in seriously injuring the old, well-established plants. It is probable that some younger plants had been killed, for the sprayed area contained fewer plants than the unsprayed lawn on either side.

This difference, though, was not marked. The only striking difference apparent at this time was that the blossoms on the unsprayed plants were several days earlier than those on the sprayed area. The grass on the sprayed area showed no injury.

This year the same sprayer and methods were used as in the previous season's work. The strength of the mixture, however, was increased from $1\frac{1}{2}$ pounds of iron sulphate per gallon of water to 2 pounds per gallon, and in three of the six sprayings the plat was given a double application, so that more sulphate was used for a given area, and each plant received a more thorough coating of spray. The applications were made two weeks apart instead of four.

Until the last of this season's spraying there is very little to add to our observations made after each spraying in 1909; a detailed statement of the effects of each spraying during 1910, therefore, is not necessary, and only a few main points will be mentioned. The black color always followed spraying and most of the dandelion foliage was killed, but the central bud of most plants usually escaped serious injury.

The first spraying was made on April 15, two days after the lawn had been mowed for the first time and just at the beginning of the blooming season. The second spraying followed two weeks later; April 30, when a double application was made; the second application being applied in an opposite direction from the first. The foliage seemed to be more thoroughly killed by this double application but the roots were still vigorous, and new tops were produced just as in previous treatments.

It was noticeable at this time that none of the plants on the sprayed area had bloomed, while the adjacent unsprayed lawn was yellow with blossoms; also, the foliage was much thinner on the sprayed area. This latter difference was due in part to the absence of a rank growth of dandelion leaves, but it is probable also that some grass blades had been killed by the spray.

The third spraying, applied on May 11, was a double one and resulted in killing most of the dandelion foliage though it was no more effective than the previous one.

The fourth spraying was made on May 28; only a single treatment was given because the grass foliage was noticeably thin, and we did not care to risk killing it entirely. The dandelion foliage was not as effectively killed by this application as when a double spraying was made. Quite a heavy rain fell on the day following this spraying and probably reduced somewhat its toxic action on the leaves.

The fifth spraying, a double application, was made on June 15; the leaves were well killed, but five days later considerable new foliage had developed.

The plat was given a sixth spraying on June 29. This was a single application, but the grass had been cut on the previous day, so the foliage was well covered. It was quite apparent at this time that the grass on the sprayed plat had been injured; little growth had been made since the previous spraying, and the plat was so dark that no guide lines were necessary to keep within the bounds of the plat. Some of the dandelions also had failed to produce foliage, and by comparing sprayed and unsprayed areas it was apparent that there were many more dandelions on the lawn adjacent to the sprayed plat. The dandelions remaining on the sprayed plat were small, but it seemed probable that there was still plenty of vitality left in the roots, which, if given an opportunity, would produce fully developed and normal tops. This treatment, like the previous ones, caused a decided blackening of the lawn and killed most of the dandelion foliage. On the 6th of August the grass was at a standstill and the plat was still dark, but the dandelions were again recovering. It was apparent after this treatment that the dandelions had been partly killed out, but it was also certain that these treatments, if continued, would kill the grass before the season was over. Therefore, it was decided not to spray again for the present; at least not until the grass had recovered enough to warrant it. After the last spraying the dandelions on the sprayed area were counted; and 1,085 plants were found alive on 1,000 square feet of lawn.

Since no more spraying was done during the season nothing further can be reported at this time, but the investigation is to be continued.

VITALITY OF THE DANDELION ROOT.

The dandelion root, when the plant is once established, stores up a large amount of reserve food, is very hardy and extremely persistent.

Prof. Bolley,⁶ after making several cutting tests on old and young dandelions in North Dakota, has the following to say concerning the vigor of the roots: "Any part of the root below the ground, when in a normal state, will send up new plants after being cut off. Plants readily send up shoots from roots that were cut three and four inches below the surface. The more often they are cut off the weaker become the offshoots."

Observations made by Munson in Maine⁷ show that the dandelion root, after having the tops removed, will in time send up from one to six new crowns, so that in many cases, and especially where lateral roots are severed from the main root, more plants result than would have been the case if the tops had remained uncut.

From our own observations it seems certain that continued cutting checks leaf growth but that the root continues to live after the top has been removed several times. The following experiment was made to learn just how many times the tops can be removed below the crown without killing the root: In a lawn on the Station grounds, two large plants were selected and marked with stakes. The tops of these plants were removed just below the crown, and all growth that appeared above ground thereafter was removed, usually, just as soon as the leaves unfolded. At no time were the leaves allowed to make more than four inches of growth. The first cutting was made on May 2, the eighth and last one on July 12. Under this treatment one of the roots continued to send up new leaves until the seventh cutting; the other lived until the tops had been removed eight times. After this both roots apparently died; at any rate no further growth appeared during the season. From the above observation we may conclude that on very small lawns, frequent and continued cutting

⁶N. Dak. Sta. Bul. 80: 564-567. March, 1906.

⁷Maine Sta. Bul. 95: 190-113. Sept., 1903.

may be effective and perhaps practicable, but on large lawns it is apparent that such treatment is entirely inadequate, at least in this region.

The above experiments ~~seem to explain~~, also, the reason for the failure of spraying to kill the larger dandelions. Spraying merely kills the leaves. The only effect on the root is to starve and weaken it in exactly the same way that frequent, close cutting of the leaves weakens it. Plants which can survive six or seven cuttings can surely stand as many sprayings and probably more, because spraying does not remove the leaves so completely as was done in our cutting experiments.

POTATO SPRAYING EXPERIMENTS IN 1910.*

F. C. STEWART, G. T. FRENCH AND F. A. SIRRINE.

SUMMARY.

This bulletin gives the results of the ninth year's work in the ten-year series of potato spraying experiments begun in 1902. During 1910 the experiments were conducted along the same lines as in previous years. Nineteen separate experiments are reported.

TEN-YEAR EXPERIMENTS.

At Geneva six sprayings increased the yield 63 bu. per acre and three sprayings increased it 22 bu. Flea beetles, early blight, late blight and rot were all factors in the experiment. The benefit from spraying was scarcely noticeable until after September 2d. At Riverhead the gain due to five sprayings was 19 bu. per acre and to three sprayings 8 $\frac{1}{3}$ bu. The plants suffered from drought, and were slightly injured by flea beetles, aphids and early blight, but there was no late blight or rot.

FARMERS' BUSINESS EXPERIMENTS.

In twelve farmers' business experiments, including 218 acres, the average gain due to spraying was 19.1 bu. per acre; the average total expense of spraying, \$4.04 per acre; and the average net profit, \$4.39. In three of the experiments spraying was unprofitable.

VOLUNTEER EXPERIMENTS.

Five volunteer experimenters reported gains averaging 68 bu. per acre.

Colorado beetles, flea beetles and tip burn were the chief troubles of potato foliage in 1910. Early blight was not destructive. The most striking event of the season was a late outbreak of late blight which caused very little injury to the foliage, but resulted in considerable loss from rot. This might have been prevented by late spraying.

*A reprint of Bulletin No. 338, corrected. May, 1911.
[90]

INTRODUCTION.

Does it pay to spray potatoes in New York? Potato growers have been asking this question for fifteen years or more. It is well known that in seasons when blight is destructive spraying will check the blight and considerably increase the yield; but the majority of potato growers have doubted that spraying is profitable on the average. They argue that blight does not appear every year. In some seasons it causes but little if any damage, yet the spraying must be done regularly because it is impossible to foretell the appearance of blight. The result is that in some seasons spraying is profitable while in others it is unprofitable and they doubt that the aggregate gain will pay the expense of spraying for a series of years.

This Station has set out to find an answer to the above question. The investigation was begun in 1902 and is to be continued until 1912. During the ten consecutive years numerous potato spraying experiments will be made each year and at the end of the period the results will be averaged. The experiments are of three kinds: (1) Station ten-year experiments; (2) farmers' business experiments; (3) farmers' volunteer experiments. The ten-year experiments (two each year) are carried out entirely by the Station. The business experiments (12 to 15 each year) are conducted by farmers in coöperation with the Station. The volunteer experiments are carried out entirely by farmers.

Bulletins previously published are:

- No. 221. Potato Spraying Experiments in 1902;
- No. 241. Potato Spraying Experiments in 1903;
- No. 264. Potato Spraying Experiments in 1904;
- No. 279. Potato Spraying Experiments in 1905;
- No. 290. Potato Spraying Experiments in 1906;
- No. 307. Potato Spraying Experiments in 1907;
- No. 311. Potato Spraying Experiments in 1908;
- No. 323. Potato Spraying Experiments in 1909.

SUMMARY OF RESULTS OBTAINED IN TEN-YEAR
EXPERIMENTS PRIOR TO 1910.

RESULTS IN 1902.

TABLE I.—YIELD BY SERIES AT GENEVA IN 1902.

Series.	Rows.*	Dates of spraying.	Yield per acre.†	
			Bu.	Lbs.
I.....	1, 4, 7 and 13.....	July 10, 23 and Aug. 12.....	317	41
II.....	2, 5, 8 and 14.....	June 25, July 10, 23, 30, Aug. 12, 26 and Sept. 10.....	342	36
III.....	3, 6, 9 and 15.....	Not sprayed.....	219	4

* Rows 10, 11 and 12 omitted because of probable error.

† The yields given in Tables I to XVI relate to marketable tubers only.

*Increase in yield due to spraying three times, 98½ bu. per acre.**Increase in yield due to spraying seven times, 123½ bu. per acre.*

The unsprayed rows died two weeks earlier than the sprayed rows, owing chiefly to a severe attack of late blight. They were also somewhat injured by flea beetles, but there was no early blight. On unsprayed rows the loss from rot was 7½ per ct.; on sprayed rows only an occasional tuber.

TABLE II.—YIELD BY SERIES AT RIVERHEAD IN 1902.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	Lbs.
I.....	2, 5, 8 and 11.....	May 26, June 20 and July 12.....	296	20
II.....	1, 4, 7 and 10.....	May 26, June 3, 20, 30, July 11, 23 and Aug. 5.....	312	35
III.....	3, 6, 9 and 12.....	Not sprayed.....	267	40

*Increase in yield due to spraying three times, 27½ bu. per acre.**Increase in yield due to spraying seven times, 45 bu. per acre.*

In this experiment there were only traces of early blight and no late blight. The larger yield on sprayed rows was due to partial protection against flea beetles which were rather plentiful at times. There was no rot.

RESULTS IN 1903.

TABLE III.—YIELD BY SERIES AT GENEVA IN 1903.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	July 14, 28 and Aug. 26.....	262	—
II.....	2, 5, 8, 11 and 14.....	July 7, 21, Aug. 7, 21 and Sept. 3.....	292	10
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	174	20

Increase in yield due to spraying three times, 88 bu. per acre.

Increase in yield due to spraying five times, 118 bu. per acre.

Three sprayings prolonged the life of the plants 11 days; five sprayings, 18 days. There was no early blight and the injury from flea beetles was only slight. Late blight was again the chief enemy. The loss from rot was even less than in 1902.

TABLE IV.—YIELD BY SERIES AT RIVERHEAD IN 1903.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7 and 10.....	June 5, July 22 and Aug. 7.....	246	45
II.....	2, 5, 8 and 11.....	June 5, 24, July 7, 22 and Aug. 7.....	263	10
III.....	3, 6, 9 and 12.....	Not sprayed.....	207	10

Increase in yield due to spraying three times, 39½ bu. per acre.

Increase in yield due to spraying five times, 56 bu. per acre.

The sprayed rows outlived those unsprayed by several days. Late blight and flea beetles were the chief enemies. Early blight, also, caused slight damage. On the unsprayed rows the loss from rot was 2 per ct.; on those sprayed, practically nothing.

RESULTS IN 1904.

TABLE V.—YIELD BY SERIES AT GENEVA IN 1904.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	July 13, 27 and Aug. 15.....	344	30
II.....	2, 5, 8, 11 and 14.....	July 8, 22 and Aug. 1, 15 and 29.....	386	40
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	153	25

Increase in yield due to spraying three times, 191 bu. per acre.

Increase in yield due to spraying five times. 233 bu. per acre.

Spraying prolonged the life of the plants 25 days. Late blight was the only trouble. On both sprayed and unsprayed rows there was a little rot at digging time. In storage, the sprayed potatoes rotted most. Spraying materially improved the cooking qualities.

TABLE VI.—YIELD BY SERIES AT RIVERHEAD IN 1904.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7 and 10.....	June 14, July 21 and Aug. 9.....	257	58
II.....	2, 5, 8 and 11.....	June 14, 27, July 11, 26, Aug. 9 and 22...	297	45
III.....	3, 6, 9 and 12.....	Not sprayed.....	201	25

Increase in yield due to spraying three times, 56½ bu. per acre.

Increase in yield due to spraying six times, 96½ bu. per acre.

The larger yield on sprayed rows was due chiefly to partial protection against flea beetles which were unusually abundant. Both early and late blight were also present. The loss from rot was 3 per ct. on Series I, 1 per ct. on Series II, and 6 per ct. on Series III.

RESULTS IN 1905.

TABLE VII.—YIELD BY SERIES AT GENEVA IN 1905.

Series.	Rows.*	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	4, 7, 10 and 13.....	July 3, Aug. 7 and 25.....	228	45
II.....	5, 8, 11 and 14.....	June 29, July 13, 27, Aug. 12 and 24.....	241	15
III.....	6, 9, 12 and 15.....	Not sprayed.....	121	52

* Rows 1, 2 and 3 omitted because of error.

Increase in yield due to spraying three times, 107 bu. per acre.

Increase in yield due to spraying five times, 119½ bu. per acre.

From the combined attack of flea beetles, tip burn and late blight the unsprayed rows died fully two weeks earlier than the sprayed ones. Spraying reduced the loss from rot at the rate of 41 bushels per acre. There was no subsequent rot in storage.

TABLE VIII.—YIELD BY SERIES AT RIVERHEAD IN 1905.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	June 14, July 18 and Aug. 11.....	253	—
II.....	2, 5, 8, 11 and 14.....	June 14, 30, July 14, 28 and Aug. 11.....	303	41
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	221	38

Increase in yield due to spraying three times, 31½ bu. per acre.

Increase in yield due to spraying five times, 82 bu. per acre.

Late blight caused no injury in this experiment and there was not even a trace of rot. Flea beetles and early blight were the enemies fought.

RESULTS IN 1906.

TABLE IX.—YIELD BY SERIES AT GENEVA IN 1906.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	July 9, Aug. 10 and 30.....	227	25
II.....	2, 5, 8, 11 and 14.....	July 6, 20, Aug. 6, 20 and 21.....	258	40
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	195	40

Increase in yield due to spraying three times, 31½ bu. per acre.

Increase in yield due to spraying five times, 63 bu. per acre.

Late blight, early blight, flea beetles and tip burn were all factors in this experiment, but none of them caused much damage. Spraying controlled blight and flea beetles completely and tip burn partially. The loss from rot was negligible, only four rotten tubers being found in the entire experiment.

TABLE X.—YIELD BY SERIES AT RIVERHEAD IN 1906.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	June 12, July 18 and Aug. 6.....	172	—
II.....	2, 5, 8, 11 and 14.....	June 12, 25, July 10, 25 and Aug. 6.....	203	45
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	150	30

Increase in yield due to spraying three times, 21½ bu. per acre.

Increase in yield due to spraying five times, 53½ bu. per acre.

In the experiment at Riverhead the principal enemies were late blight and flea beetles, there being a moderate attack of both. Early blight was not sufficiently abundant to cause material injury. There was no loss from rot.

RESULTS IN 1907.

TABLE XI.—YIELD BY SERIES AT GENEVA IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	July 15, Aug. 9 and 24.....	220	15
II.....	2, 5, 8, 11 and 14.....	July 15, 24, Aug. 9, 24 and Sept. 17.....	249	50
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	176	10

Increase in yield due to spraying three times, 44 bu. per acre.

Increase in yield due to spraying five times, 73½ bu. per acre.

Late blight and rot were wholly absent and early blight appeared only in traces. There was some tip burn and a light attack of flea beetles. Considering the seemingly small amount of damage done by blight and insects it is remarkable that spraying should have increased the yield so much.

TABLE XII.—YIELD BY SERIES AT RIVERHEAD IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	June 19, July 25 and Aug. 15.....	186	45
II.....	2, 5, 8, 11 and 14.....	June 19, July 2, 17, 31, Aug. 15 and 29....	200	5
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	168	50

Increase in yield due to spraying three times, 18 bu. per acre.

Increase in yield due to spraying six times, 31¼ bu. per acre.

There was some early blight, but no late blight. Flea beetles were plentiful and caused much damage. The larger yield of the sprayed rows is to be attributed to their partial protection against flea beetles and early blight.

RESULTS IN 1908.

TABLE XIII.—YIELD BY SERIES AT GENEVA IN 1908.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	July 3, 17 and Aug. 3.....	155	40
II.....	2, 5, 8, 11 and 14.....	July 3, 17, Aug. 3, 18, Sept. 1 and 16.....	165	10
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	126	10

Increase in yield due to spraying three times, 29½ bu. per acre.

Increase in yield due to spraying six times, 39 bu. per acre.

There was no early blight, no late blight and no rot. Flea beetles caused slight damage to the unsprayed rows, most of which occurred after September 1st. The chief trouble was tip burn, which was quite severe. The sprayed rows of Series II outlived the unsprayed rows of Series III by about five days owing, apparently, to the smaller amount of tip burn and flea beetle injury on the sprayed rows.

TABLE XIV.—YIELD BY SERIES AT RIVERHEAD IN 1908.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	June 11, July 9 and Aug. 4.....	147	35
II.....	2, 5, 8, 11 and 14.....	June 11, 25, July 9, 24 and Aug. 4.....	152	10
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	136	50

Increase in yield due to spraying three times, 10¾ bu. per acre.

Increase in yield due to spraying five times, 15½ bu. per acre.

In this experiment there was some early blight and a moderate attack of flea beetles, but no late blight and no rot. During July considerable damage was done by aphids which were not checked by the spraying.

RESULTS IN 1909.

TABLE XV.—YIELD BY SERIES AT GENEVA IN 1909.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	July 9, 23 and Aug. 11.....	162	20
II.....	2, 5, 8, 11 and 14.....	July 9, 23, Aug. 11, 27, Sept. 10 and 24..	173	25
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	123	40

Increase in yield due to spraying three times, 38½ bu. per acre.

Increase in yield due to spraying six times, 49½ bu. per acre.

Early blight, late blight and rot were all absent. Some injury from flea beetles was noticeable throughout the season. After September 1 there was considerable tip burn. As late as September 24 the difference between sprayed and unsprayed rows appeared slight. The sprayed rows held most of their foliage until killed by frost on October 14.

TABLE XVI.—YIELD BY SERIES AT RIVERHEAD IN 1909.

Series.	Rows.	Dates of spraying.	Yield per acre.*	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.....	June 11, July 16 and 31.....	136	30
II.....	2, 5, 8, 11 and 14.....	June 11, 25, July 9, 24, Aug. 6 and 21....	160	20
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	107	50

* Marketable tubers only. Owing to their small average size it was deemed advisable to make two grades of the marketable tubers; "firsts" which sold for 80 cents per bushel and "seconds" which sold for 40 cents. The increase in yield due to spraying was chiefly in the grade of "firsts," the yields being as follows:

Rows sprayed three times, 75½ bu. "firsts" and 61½ bu. "seconds;" rows sprayed six times, 100 bu. "firsts" and 60½ bu. "seconds;" unsprayed rows, 50 bu. "firsts" and 57½ bu. "seconds."

Increase in yield due to spraying three times, 28½ bu. per acre.

Increase in yield due to spraying six times, 52½ bu. per acre.

There was a little early blight, but no late blight and no rot. After July 15 the plants suffered from both drought and flea beetles. From this time until the plants were all dead the sprayed rows were noticeably superior to the unsprayed ones. This difference was more marked during the last week in July than on August 21.

DETAILS OF THE TEN-YEAR EXPERIMENTS IN 1910.

AT GENEVA.

In 1910, the experiment was carried out in practically the same manner as in previous years. As usual, there were 15 rows¹ 290.4 feet long by 3 feet wide. Planting was done by hand on June 1. The variety was Rural New Yorker No. 2. Each row received 10 pounds of chemical fertilizer applied by hand as uniformly as possible in the open furrow at planting time. The plat of land used lay adjacent to that used for the experiment in 1908 and 1909. The soil was heavy clay loam and there was good surface drainage. Although the tubers used for seed bore sprouts 3 to 5 inches long which were broken off in planting, practically a full stand of vigorous plants was obtained.

The five rows constituting Series I were sprayed three times with bordeaux — July 6, 20 and August 3.

The five rows constituting Series II were sprayed six times with bordeaux — July 6, 20, August 3, 18, September 2 and 19.

The five rows constituting Series III (check) were not sprayed at all with bordeaux.

Colorado potato beetles or "bugs" were eliminated from the experiment by means of paris green applied over the entire field three times — July 6, 13 and 20. The first and third of these applications were made on the dates of the first two sprayings, the paris green being applied with the bordeaux used on Series I and II and with lime water on Series III. On July 13 the whole field was treated with paris green in lime water. Probably, this treatment would have been unnecessary had more paris green been used in the application of July 6. In all cases the proportion of paris green was eight ounces to 50 gallons.

In each spraying the work was done very thoroughly with a knapsack sprayer, using 125 to 250 gallons of bordeaux per acre. The bordeaux used contained six pounds of copper sulphate in

¹ Besides the 15 rows in the experiment proper there were, as in all previous experiments, two other rows which served the purpose of outside rows.

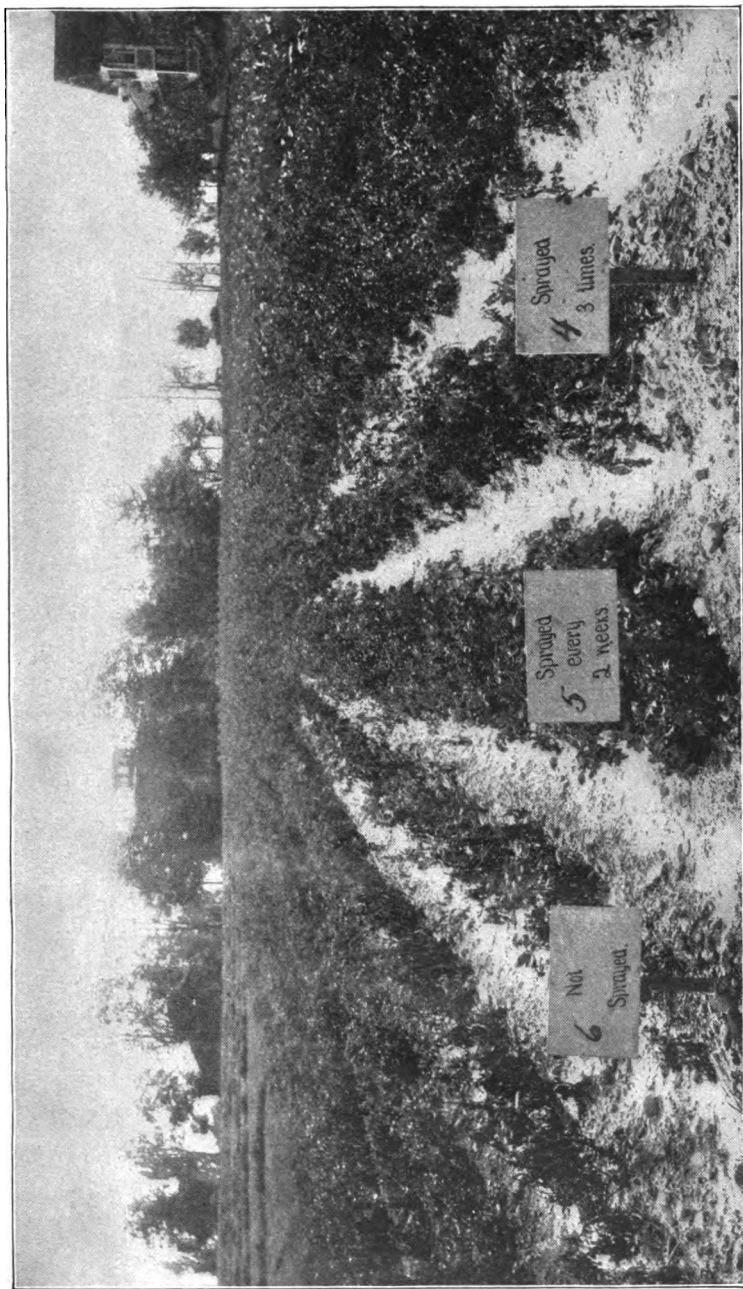


PLATE I.—ROWS 6, 5 AND 4 IN TEN-YEAR EXPERIMENT AT GENEVA.
 Foliage on Row 4 and Row 6 dead and brown from late blight; Row 5 all green.
 (Bare ground whitened with air-slaked lime. Photographed October 3, 1910.)

each 50 gallons, and lime somewhat in excess of the quantity required to satisfy the potassium ferrocyanide test.

On September 2 the foliage of all three series was practically perfect. There was no appreciable difference between sprayed and unsprayed rows except, perhaps, the latter showed a trifle more flea-beetle injury.

On September 19 late blight, *Phytophthora infestans*, was discovered near the north end of the experiment in the lowest part of the field. Over a section about 25 feet long on Rows 6 and 7 the plants had already lost about one-third of their foliage from late blight and traces of the disease were found on four or five other rows on the east or down hill side of the field.

The weather being wet the disease spread rapidly. The rows of Series I (sprayed three times) succumbed almost as readily as the check rows. By October 3 Rows 3, 4, 6, 7, 9 and 10 were practically dead over a distance of about 90 feet from the north end. In the same region, Rows 1, 12 and 13 retained about one-third of their foliage and Row 15 about two-thirds, while Rows 2, 5, 8, 11 and 14 (sprayed six times) were still in full foliage and showing only traces of blight (Plate I). A week later, the contrast was still more striking.

The south two-thirds of the field was not attacked by late blight, but a little early blight appeared here toward the close of the season. In this part of the experiment the difference between sprayed and unsprayed rows appeared slight. On the rows of Series II about three-fourths of the foliage was still green at the time of the first killing frost which occurred on the night of October 12.

The potatoes were dug by hand and sorted and weighed in the usual manner. In the north third of the experiment a considerable number of rotten tubers were found. These were weighed separately. The yield by rows is shown in the following table:

TABLE XVII.—YIELDS IN THE EXPERIMENT AT GENEVA IN 1910.

Row.	TREATMENT.	YIELD PER ROW.*			YIELD PER ACRE.					
		Market-able.	Culls.	Rotten.	Market-able.	Culls.	Rotten.	Market-able.	Culls.	Rotten.
		lbs.	lbs.	lbs.	Bu.	lbs.	Bu.	lbs.	Bu.	lbs.
1	Sprayed 3 times.....	262	8	20	218	20	6	40	16	40
2	Sprayed 6 times.....	328	6	3 $\frac{1}{2}$	273	20	5	—	2	55
3	Unsprayed.....	243	8	15 $\frac{1}{2}$	202	30	6	4	12	55
4	Sprayed 3 times.....	284 $\frac{1}{2}$	5	14 $\frac{1}{2}$	237	5	4	10	12	5
5	Sprayed 6 times.....	363 $\frac{1}{2}$	7 $\frac{1}{2}$	6	302	55	6	15	5	—
6	Unsprayed.....	248	9	14	206	40	7	30	11	40
7	Sprayed 3 times.....	295	7	24	245	50	5	50	20	—
8	Sprayed 6 times.....	293 $\frac{1}{2}$	6	5	244	10	5	—	4	10
9	Unsprayed.....	282	4	19	235	—	3	20	15	50
10	Sprayed 3 times.....	297 $\frac{1}{2}$	5	17 $\frac{1}{2}$	247	55	4	10	14	35
11	Sprayed 6 times.....	367	7	7	305	50	5	50	5	50
12	Unsprayed.....	260 $\frac{1}{2}$	7	17	217	5	5	50	14	10
13	Sprayed 3 times.....	328	6	10	273	20	5	—	8	20
14	Sprayed 6 times.....	361	7	0	300	50	5	50	—	—
15	Unsprayed.....	302	7	9	251	40	5	50	7	30

* Rows 290.4 feet long by 3 feet wide, making the area of each row exactly one-fiftieth acre.

† Row 8 fell in a dead furrow. This accounts for its low yield.

The five rows sprayed three times constitute Series I and the average yield of these rows makes the yield for Series I. The yields given for Series II and III have been computed in the same way. The yield by series is shown in the following table:

TABLE XVIII.—YIELD BY SERIES AT GENEVA IN 1910.

Series.	Rows.	Dates of spraying.	Yield per acre.*	
I.....	1, 4, 7, 10 and 13.....	July 6, 20 and Aug. 3.....	Bu.	lbs.
II.....	2, 5, 8, 11 and 14.....	July 6, 20, Aug. 3, 18, Sept. 2 and 10.....	244	30
III.....	3, 6, 9, 12 and 15.....	Not sprayed.....	285	25
			222	35

* Marketable tubers only.

Increase in yield due to spraying three times, 22 bu. per acre.

Increase in yield due to spraying six times, 63 bu. per acre.

Loss from rot.—In the north one-third of the experiment field, where the plants were attacked by late blight, a considerable number of rotten tubers were found. Most of the affected tubers were in the early stages of rot; very few were wholly destroyed.

Some were so slightly affected as to make it difficult to detect them and it is probable that some were overlooked in sorting. Hence, the yields of rotten tubers given in the last column of Table XVII are only approximate. According to the figures given in this table, the average loss per acre from rot was 14.33 bu. on Series I, 3.6 bu. on Series II, and 12.4 bu. on Series III; but as all of this rot occurred on the north one-third of the field the rate of loss in this part of the field was three times these amounts, namely, 43 bu. per acre on Series I, 10.8 bu. per acre on Series II, and 37.2 bu. per acre on Series III. Apparently, three sprayings slightly increased rather than diminished the loss from rot while six sprayings reduced it at the rate of 26.4 bu. per acre. Under the conditions obtaining in this experiment it could not be expected that spraying would wholly prevent rot.

AT RIVERHEAD.

The experiment at Riverhead was carried out in practically the same manner as the one at Geneva. There were fifteen rows 290.4 feet long by three feet wide. The potatoes were of the variety Carman No. 1. They were planted on April 14. The soil was sandy loam.

The five rows of Series I were sprayed with bordeaux mixture three times — June 20, July 16 and August 1.

The five rows of Series II were sprayed with bordeaux mixture five times — June 20, July 3, 16, August 1 and 13.

The five rows of Series III (check) received no bordeaux.

The bordeaux mixture was prepared and applied in the same manner as at Geneva. The plants suffered severely from drought and were moderately attacked by flea beetles, plant lice and early blight; but late blight and rot were wholly absent.

Owing to a misunderstanding by the man in charge of the digging, the potatoes were not sorted into two grades (marketable tubers and culls) according to our usual custom. Hence, the yields given are for unsorted potatoes. Table XIX shows the yield by rows and Table XX the yield by series.

TABLE XIX.—YIELDS IN THE EXPERIMENT AT RIVERHEAD IN 1910.

Row.	TREATMENT.	Yield per row.		Yield per acre.	
		<i>lbs.</i>	<i>Bu.</i>	<i>lbs.</i>	<i>Bu.</i>
1	Sprayed 3 times.....	246	205	—	—
2	Sprayed 5 times.....	131*	109	10	10
3	Unsprayed.....	203	169	10	10
4	Sprayed 3 times.....	184	153	20	20
5	Sprayed 5 times.....	212	176	40	40
6	Unsprayed.....	182	151	40	40
7	Sprayed 3 times.....	197	164	10	10
8	Sprayed 5 times.....	207	172	30	30
9	Unsprayed.....	151	125	50	50
10	Sprayed 3 times.....	200	166	40	40
11	Sprayed 5 times.....	215	179	10	10
12	Unsprayed.....	191	159	10	10
13	Sprayed 3 times.....	205	170	50	50
14	Sprayed 5 times.....	203	169	10	10
15	Unsprayed.....	191	159	10	10

* The cause of the irregular yields on rows 1 and 2 is unknown.

TABLE XX.—YIELD IN SERIES AT RIVERHEAD IN 1910.†

Series.	Rows.	Dates of spraying.	Yield per acre.	
			<i>Bu.</i>	<i>lbs.</i>
I.....	4, 7, 10 and 13.....	June 20, July 16 and Aug. 1.....	163	45
II.....	5, 8, 11 and 14.....	June 20, July 3, 16, Aug. 1 and 13.....	174	22
III.....	6, 9, 12 and 15.....	Not sprayed.....	148	57

† Incorrectly reported in Bulletin 338. Rows 1, 2 and 3 should be omitted because of error.

Increase in yield due to spraying three times, 14½ bu. per acre.

Increase in yield due to spraying five times, 25½ bu. per acre.

SUMMARY OF RESULTS OBTAINED IN THE TEN-YEAR EXPERIMENTS, 1902-1910.

The following table shows the results obtained in the ten-year experiments during the first nine years:

TABLE XXI.—SUMMARY OF THE TEN-YEAR EXPERIMENTS FOR NINE YEARS.

YEAR.	AT GENEVA.		AT RIVERHEAD.	
	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.
1902.....	<i>Bu.</i> 123½	<i>Bu.</i> 98½	<i>Bu.</i> 45	<i>Bu.</i> 27½
1903.....	118	88	56	39½
1904.....	233	191	96	56½
1905.....	119	107	82	31½
1906.....	63	32	53	21½
1907.....	73½	44	31	18
1908.....	39	29½	15½	10½
1909.....	49½	38½	52½	28½
1910.....	63	22	25½	14½
Average.....	98	72+	51—	28—

FARMERS' BUSINESS EXPERIMENTS.

During the season of 1910 twelve farmers in different parts of the State conducted business experiments for the Station. The object of these experiments is to determine the actual profit in spraying potatoes under farm conditions. The methods employed were essentially the same as in previous years. An accurate record was kept of all of the expense of spraying, including labor, chemicals and wear of machinery. In each experiment a strip of three to six rows was left unsprayed for comparison.

"Spraying," as used in this bulletin, means the application of bordeaux mixture exclusively. The application of paris green or arsenite of soda in lime water is not called spraying.

Whenever "arsenite of soda" is mentioned it should be understood to mean the stock solution prepared by the Kedzie formula — one pound white arsenic, four pounds sal soda and one gallon of water boiled together twenty minutes.

By "test rows" is meant the rows used in determining the amount of the increase in yield due to spraying. These are, usually, the middle unsprayed row and the second sprayed row on either side.

Unless otherwise stated, the yields given are for marketable tubers only.

The price used in computing the value of the increased yield is, in every case, the market price for potatoes in the locality where the experiment was made on the date on which the test rows were dug.

In order to bring the account of the experiments within the required space limit it has been necessary to omit many interesting details.

THE LANCASTER EXPERIMENT

Conducted by John Engler, Lancaster, N. Y. Ten acres of potatoes, planted about June 27, were sprayed twice (August 25 and September 12 and 13) with bordeaux mixture, formula 5-5-50.¹ In the first spraying an "Aspinwall" sprayer was used; in the second, an "Iron Age" sprayer. Both are one-horse, four-row machines. The potato field was about 500 yards from the water supply. The water was pumped by hand. Four rows, 643.5 feet long by 32 inches wide, were left unsprayed for a check. Owing to the absence of bugs it was unnecessary to use any poison, either on the sprayed or the unsprayed rows. There were few flea beetles and the only disease affecting the plants was a very mild attack of the late blight which resulted in some rot, but came too late to cause material injury to the foliage.

The items of expense were as follows:

86 lbs. copper sulphate @ 6c.....	\$5 16
100 lbs. lime.....	70
20 hrs. labor for man @ 20c.....	4 00
20 hrs. labor for horse @ 15c.....	3 00
Wear on sprayer.....	1 00
Total.....	<u>\$13 86</u>

Expense of spraying one acre once, 73 cents.

Expense of spraying one acre twice, \$1.46.

The yields were as follows:

Two rows sprayed twice, 1,010.5 lbs.=213.9 bu. per acre.

Two unsprayed rows, 922.5 lbs.=195.3 bu. per acre.

Gain from spraying, 18.6 bu. per acre.

On the two sprayed rows there were only two pounds of rotten tubers, while on the two unsprayed rows there were 136.5 lbs. (=28.9 bu. per acre) of rotten tubers. Had there been no rot, the unsprayed rows would have outyielded the sprayed ones.

At fifty cents per bushel 18.6 bushels of potatoes are worth \$9.30. Subtracting the expense of spraying, \$1.46, we have left a net profit of \$7.84 per acre.

¹ About one acre was omitted in the second spraying.

THE BATAVIA EXPERIMENT.

Conducted by G. A. Prole, Batavia, N. Y. Thirteen acres of potatoes were sprayed four times with a two-horse, four-row "Iron Age" sprayer carrying one nozzle per row. The dates of spraying were July 8, 15, August 5 and 30. Water was obtained from a well about ten rods from the field. The pumping was done by a windmill. Poison (arsenite of soda) was used with the bordeaux in the first two sprayings at the rate of three quarts of the stock solution to 50 gallons and in the last spraying at the rate of four quarts to 50 gallons. The check consisted of a strip of three unsprayed rows 1,600 feet long and 32 inches apart. These were treated three times (July 8, 15 and August 30) with paris green for bugs which were plentiful and difficult to control. Toward the close of the season the sprayed rows appeared slightly superior to the checks. Although no late blight was observed there must have been a little in the field because some rot was formed on the test rows at digging time. Another spraying, made in September, would probably have prevented this rot.

The expense account contained the following items:

192 lbs. copper sulphate @ 6c.....	\$11 52
2 bu. lime @ 25c.....	50
71 lbs. sal soda @ 1½c.....	1 07
18 lbs. white arsenic @ 12½c.....	2 25
4 days' labor for man @ \$2.....	8 00
8 days' labor for horse @ 50c.....	4 00
Wear on sprayer.....	5 00
Total.....	<u>\$32 34</u>

The test rows (variety Noxall) yielded as follows:

Two sprayed rows, 2,266 lbs.= 181.5 bu. per acre.

Middle unsprayed row, 984 lbs.= 157.6 bu. per acre.

Gain from spraying, 23.9 bu. per acre.

On the sprayed rows there were 10.7 bu. of rotten tubers per acre; on the unsprayed rows, 15.4 bu.

Potatoes being worth 35 cents per bushel, the gain of 23.9 bu. has a value of \$8.36. After subtracting \$2.49, the expense of spraying, there remains a net profit of \$5.87 per acre.

THE ALBION EXPERIMENT.

Conducted by Ora Lee, Jr., Albion, N. Y. Twenty acres of potatoes (variety Sir Walter Raleigh) were sprayed eight times between June 25 and September 8. The spraying outfit consisted, essentially, of a 250-gallon tank and a Friend pump worked by a gasoline engine. It was mounted on a four-wheeled cart drawn by two horses. Ten rows were covered at each passage. The bordeaux used contained, in the first five sprayings, 20 lbs. and in the last three sprayings, 25 lbs. of copper sulphate to each 250 gallons. It had to be drawn 20 to 150 rods. Arsenate of lead, at the rate of 16 lbs. to 250 gallons, was used with the bordeaux in the first, second and fourth sprayings. On the same dates the same poison (with water) was applied to the check which consisted of ten rows 960 feet long by 32 inches wide. Some difference between sprayed and unsprayed rows was noticeable during the last three or four weeks of growth, owing probably to the better control of flea beetles on the sprayed rows. There seems to have been no blight of importance. No rotten tubers were found at digging time.

The items of expense were as follows:

390 lbs. copper sulphate @ \$4.60 per cwt.....	\$17 94
454 lbs. copper sulphate @ \$4.65 per cwt.....	21 11
8 bbl. lime @ \$1.15.....	9 20
75 hrs. labor for man @ 15c.....	11 25
120 hrs. labor for horse @ 15c.....	18 00
15 gal. gasoline @ 17c.....	2 55
1 gal. machine oil.....	60
1 qt. cylinder oil.....	35
Wear of sprayer.....	40 00
Total.....	\$121 00

The yields of unsorted potatoes were as follows:

Ten sprayed rows,² 9,290 lbs.= 263.5 bu. per acre.

Ten unsprayed rows, 8,304 lbs.= 235.5 bu. per acre.

Gain due to spraying, 28 bu. per acre, worth, at 40 cents per bushel, \$11.20. After deducting the expense of spraying, \$6.05 per acre, there remains *a net profit of \$5.15 per acre.*

² Five rows on either side of the check.

THE ANDOVER EXPERIMENT.

Conducted by J. M. Greene & Son, Andover, N. Y. Six acres of potatoes were sprayed four times (July 18, 23, Aug. 7 and 23) with bordeaux of the 5-5-50 formula. Four rows were left for a check. In order to compare double with single spraying four rows next to the check on the south side were double sprayed at each spraying. The sprayer used was a two-horse "Watson" covering four rows at each passage. One nozzle per row was used in the first spraying and two nozzles per row in the last three sprayings. Water for the preparation of the bordeaux was taken from a stream about eighty rods from the potato field. For the control of bugs arsenite of soda was applied with the bordeaux in the first two sprayings. In the first spraying it was used at the rate of four quarts of the stock solution to 50 gallons of bordeaux, but as this injured the plants slightly the quantity was reduced one-half in the second spraying. The check rows also, were treated twice with arsenite of soda in lime water and somewhat injured by it.³ In the latter part of the season there was considerable contrast between sprayed and unsprayed rows. This was due partly to the better control of flea beetles on the sprayed rows and partly to the greater amount of arsenic injury on the unsprayed rows. Both early and late blight were absent and there was no rot.

The items of expense were as follows:

168 lbs. copper sulphate @ 5c.....	\$8 40
168 lbs. hydrated lime @ 1c.....	1 68
14 lbs. white arsenic @ 7c.....	98
40 lbs. sal soda @ 2c.....	80
Labor for man and team and allowance for wear of sprayer, estimated @ 40c per acre.....	9 60
Total.....	<u>\$21 46</u>

In order to determine how much the yield had been increased by spraying, three full rows (532 feet by 3 feet wide)

³ This was a mistake. Arsenite of soda should be used *only with bordeaux*, and no stronger than three quarts to 50 gallons. See Bul. 267 of this Station.

and 100-foot sections of three other rows were dug and weighed on October 5. In the accompanying diagram these rows are indicated by dotted lines and followed by their rate of yield.

DIAGRAM I.—SHOWING LOCATION AND YIELDS OF TEST ROWS IN THE ANDOVER EXPERIMENT.

Single-sprayed four times	.....	130.7 bu. per a.
		
		
Check.....	.....	99.2 bu. per a.
	.....	109.6 bu. per a.
		
Double-sprayed four times	.....	181.5 bu. per a.
	.....	204.2 bu. per a.
	.....	145.1 bu. per a.
Single-sprayed four times	.....	
		
		

Average yield of double-sprayed rows, 192.8 bu. per acre.

Average yield of single-sprayed rows, 137.9 bu. per acre.

Average yield of unsprayed rows, 104.4 bu. per acre.

Gain due to single-spraying, 33.5 bu. per acre.

Gain due to double-spraying, 88.4 bu. per acre.

Doubling the spraying more than doubled the gain.

With potatoes selling at 35 cts. per bushel, 33.5 bu. would have a value of \$11.72. Subtracting from this the expense of spraying, \$3.58 per acre, there remains \$8.14 per acre as the net profit from single-spraying four times. Computed in the same manner, the net profit from double-spraying four times was \$23.78 per acre.

THE ELMIRA EXPERIMENT.

Conducted by John Strouse, Elmira, N. Y. Sixteen acres of potatoes (in two fields) were sprayed twice with bordeaux, 6-6-50 formula. One field was sprayed on July 9 and 16 and the other on July 14 and 21. A check, consisting of three unsprayed rows, was left in each field. The sprayer used was a two-horse "Perfection" covering six rows at each passage with one nozzle per row. Arsenate of lead and paris green were used with the bordeaux for the control of bugs which were troublesome. The unsprayed rows, also, were properly poisoned. Owing to the drought there was no late blight and no rot. Neither was there any early blight and flea beetles caused only a small amount of damage. There was no appreciable difference between sprayed and unsprayed rows at any time during the season.

The expense of spraying was as follows:

174 lbs. copper sulphate @ 5.6c.....	\$9 75
174 lbs. lime.....	1 30
Sal soda and white arsenic.....	50
87 lbs. arsenate of lead @ 13½c.....	11 74
6 lbs. paris green @ 30c.....	1 80
17 hrs. labor for man @ 15c.....	2 55
17 hrs. labor for team @ 40c.....	6 80
Wear of sprayer.....	3 50
Total.....	\$37 94

The yields of the test rows were as follows:

East field.—Variety Carman No. 3; rows 500 x 3 ft.

Two sprayed rows, 705 lbs.=170.6 bu. per acre.

Middle unsprayed row, 388 lbs.=187.8 bu. per acre.

Loss, 17.2 bu. per acre.

West field.—Variety Sir Walter Raleigh; rows 93 x 3 ft.

Two sprayed rows, 114 lbs.=148.3 bu. per acre.

Middle unsprayed row, 69 lbs.=179.5 bu. per acre.

Loss, 31.2 bu. per acre.

The average loss in the two experiments was 24.2 bu. per acre. It is not known why the unsprayed rows outyielded the sprayed ones. Potatoes being worth 50 cts. per bushel the total loss from spraying in this experiment was \$14.47 per acre.

THE STERLING STATION EXPERIMENT.

Conducted by A. E. Curtis, Sterling Station, N. Y. The experiment included twelve acres of potatoes in three fields with a check of three unsprayed rows in each field. Two of the fields were sprayed seven times and the other five times, the total acreage sprayed being equal to $75\frac{1}{3}$ acres sprayed once. In all three fields a strip of six rows on each side of the check was double-sprayed, in opposite directions, at each application. The sprayer used was a two-horse, six-row, home-made affair carrying one nozzle per row. Bugs were controlled by one application of poison (paris green and arsenite of soda) with the bordeaux on the sprayed rows and paris green in water on the checks. Flea beetles and tip burn (due to dry weather) were the only important troubles in this experiment. The foliage of single-sprayed rows appeared but slightly, if at all, superior to that of the check rows, but the double-sprayed rows lived seven to ten days longer than the checks.

The expense account contained the following items:

350 lbs. copper sulphate @ $4\frac{1}{2}$ c.....	\$15 75
3 bbl. lime @ \$1.65.....	4 95
Freight on copper sulphate.....	1 00
Sal soda and white arsenic.....	6 66
60 hrs. labor for man @ 15c.....	9 00
90 hrs. labor for horse @ 10c.....	9 00
Wear on sprayer.....	5 00
Total.....	<u>\$51 36</u>

The yields were as follows⁴:

Field No. 1.— Sprayed seven times; rows 906 x 3 ft.

Two double-sprayed rows, 1,565 lbs = 207.9 bu. per acre.

One single-sprayed row, 597 lbs. = 159.4 bu. per acre.

Two check rows, 1,258 lbs. = 167.9 bu. per acre.

Loss from single-spraying, 8.5 bu. per acre.

Gain from double-spraying, 40 bu. per acre.

⁴ The potatoes were not sorted. There were few small ones.

Field No. 2.—Sprayed seven times; rows 379 x 3 ft.

Double-sprayed row, 350 lbs.= 223.5 bu per acre.

Single-sprayed row, 270 lbs.= 172.4 bu. per acre.

Check row, 267, lbs.= 170.5 bu. per acre.

Gain from single-spraying, 1.9 bu. per acre.

Gain from double-spraying, 53 bu. per acre.

Field No. 3.—Sprayed five times; rows 387 x 3 ft.

Double-sprayed row, 261 lbs.= 163.2 bu. per acre.

Single-sprayed row, 254 lbs.= 158.8 bu. per acre.

Check row, 248 lbs.= 155 bu. per acre.

Gain from single-spraying, 3.8 bu. per acre.

Gain from double-spraying, 8.2 bu. per acre.

Upon averaging the results in the three tests it is found that single-spraying resulted in an average loss of 0.9 bu. per acre, while double-spraying gave an average increase in yield of 33.7 bu. per acre. The average expense of spraying was \$4.28 per acre, and the market price of potatoes at digging time 35 cents per bushel. Hence, single-spraying resulted in a total loss of \$4.60 per acre, while double-spraying resulted in a net profit of \$3.24 per acre. This experiment is particularly instructive. It shows that thorough spraying may prove profitable where ordinary spraying, such as practiced by many potato growers, is unprofitable under exactly parallel conditions. Probably, the majority of potato growers in New York do not spray thoroughly enough to secure the maximum net profit.

THE CHATEAUGAY EXPERIMENT.

Conducted by O. Smith & Son, Chateaugay, N. Y. Eighteen acres were sprayed four times with a one-horse, four-row, "Iron Age" sprayer carrying one nozzle per row, in the first three sprayings and two nozzles per row in the last spraying. Arsenite of soda (3 qts. in 50 gals.) was used with the bordeaux three times. There were two checks of three rows each. These were treated four times with paris green in water. Four rows on either side of both checks were double-sprayed. On August 30 there was no apparent difference between sprayed and unsprayed rows. There was some flea-beetle injury and much tip-burn, but no blight or rot.

The items of expense were as follows:

432 lbs. copper sulphate @ 6c.....	\$25 92
3 bbl. lime.....	3 30
Sal soda and white arsenic.....	9 00
67½ hrs. labor for man @ 15c.....	10 15
49½ hrs. labor for horse @ 10c.....	4 95
Wear of sprayer.....	10 00
Total.....	\$63 32

The test rows (var. Enormous No. 9) gave the following yields:

East test.— Rows 806 ft. long by 3 ft. wide.

Two double-sprayed rows,^{*} 1,225 lbs. (756+499 lbs.) = 188.3 bu. per acre. Middle check row, 488 lbs. = 146.5 bu. per acre.

Gain from spraying, 41.8 bu. per acre.

West test.— Rows 1,277 ft. long by 3 ft. wide.

Two double-sprayed rows, 1,447 lbs. (829+618 lbs.) = 137.1 bu. per acre. Middle check row, 602 lbs. = 114.1 bu. per acre.

Gain from spraying, 23 bu. per acre.

The average gain was 32.4 bu. per acre worth \$11.34.

Subtracting the expense of four double-sprayings (\$7.04) we have left a net profit of \$4.30 per acre.

These sprayed potatoes in storage showed little rot, while unsprayed potatoes stored near Chateaugay rotted badly.

^{*} Unfortunately, the yield of no single-sprayed row was obtained. A noteworthy feature of this experiment is the wide variation in yield between the two sprayed rows on opposite sides of the check in both tests. In the East test a portion of one sprayed row was injured by overflowing of water, but for the difference in the West test no explanation is known.

THE PLATTSBURGH EXPERIMENT.

Conducted by Pardy Bros., Plattsburgh, N. Y. Thirteen acres of potatoes (variety, Rose of Erin) were sprayed five times — July 11, 18–20, August 12, 27 and September 13–14. The spraying was done with a two-horse, six row “Aroostook” sprayer carrying one nozzle per row. In three sprayings the bordeaux used was of the 6–6–50 formula and in the other two, 5–5–50 formula. The potato field was about 100 rods from the water supply. Six rows were left unsprayed for a check. These received four applications of arsenate of lead in water. On the sprayed portion of the field arsenite of soda was mixed with the bordeaux (3 qts. to 50 gals.), in all five sprayings. In addition, the entire field was treated with arsenate of lead in water on July 5. Consequently, bugs were well controlled. The foliage troubles were early blight, flea-beetle injury, tip burn and traces of late blight (late in the season), but no rot was found at digging time.* After September 11, the sprayed rows appeared slightly superior to the unsprayed.

The items of expense were as follows:

318 lbs. copper sulphate @ 6c.....	\$19 08
2 bbl. lime @ \$1.25.....	2 50
216 lbs. sal soda @ \$1.10 per cwt.....	2 38
108 lbs. white arsenic @ 9c.....	9 72
56 lbs. arsenate of lead @ 11c.....	6 16
79 hrs. labor for man @ 15c.....	11 85
52½ hrs. labor for team @ 20c.....	10 50
Wear of sprayer	6 50
Total.....	<u>\$66 89</u>

The test rows (366 x 3 ft.) yielded as follows:

Two sprayed rows, 378 lbs. = 125 bu. per acre.

Two check rows, 394 lbs. = 130.3 bu. per acre.

Loss, 5.3 bu. per acre.

The expense of spraying (\$5.28 per acre) plus the loss of 5.3 bu. of potatoes (worth \$2.12) makes the total loss in this experiment \$7.40 per acre.

* Pardy Brothers state that their loss from rot in storage was less than one per ct., notwithstanding the potatoes were taken to the cellar as soon as dug and piled five feet deep.

THE GREENWICH EXPERIMENT.

Conducted by P. C. Billings, Greenwich, N. Y. Five and one-half acres were sprayed twice and about half of the field a third time, the dates being July 5, 15 and August 6. In the first spraying 5-5-50 bordeaux was used; in the second, 6-6-50; and in the third, 7-7-50. The sprayer was a two-horse, six-row "Aroostook" carrying one nozzle per row. There were three check rows. In the third spraying, the adjacent six rows on either side of the check were double-sprayed. Hence, the increase in yield obtained must be regarded as the result of four sprayings. Bugs were well controlled by the use of paris green. There was a little early blight; also, some flea-beetle injury which was augmented by dry weather. No late blight was observed on September 2, but it must have appeared later, since a few rotten tubers were found at digging time. After August 15 there was considerable contrast between sprayed and unsprayed rows.

The items of expense for spraying $5\frac{1}{2}$ acres $2\frac{1}{2}$ times were as follows:

85 lbs. copper sulphate @ 6½c.....	\$5 52
85 lbs. lime.....	1 13
16 lbs. paris green @ 25c.....	4 00
12 hrs. labor for man @ 20c.....	2 40
12 hrs. labor for team @ 30c.....	3 60
Wear of sprayer.....	2 50
Total.....	<u>\$19 15</u>

Expense of spraying one acre once, \$1.44.

Expense of spraying one acre four times, \$5.76.

The test rows were of the variety Noxall. They were 761 ft. long by 3 ft. wide. The yields were as follows:

Two sprayed rows, 1,241 lbs.= 197.3 bu. per acre.

Middle check row, 488 lbs.= 155.2 bu. per acre.

Gain from spraying, 42.1 bu. per acre.

The expense of spraying being \$5.76 per acre for four applications and the value of the increased yield (42.1 bu. at 30 cents) \$12.63, the spraying in this experiment resulted in a *net profit of \$6.87 per acre.*

THE GLEN HEAD EXPERIMENT.

Conducted by G. T. Powell, Glen Head, Long Island. Fifteen acres of potatoes were sprayed four times with bordeaux (1-to-8 formula) on the following dates: June 15, 24, July 9 and 20. The sprayer used was a one-horse, four-row "Sparamotor" carrying two nozzles per row. The water required was pumped by a gasoline engine from a well about 40 rods from the field. A strip of four rows was left unsprayed for a check. Four rows on each side of the check were double-sprayed at each spraying. Bugs were controlled on the sprayed rows by adding three quarts of arsenite of soda stock solution to each 50 gallons of bordeaux in the first two sprayings and on the check rows by two applications of paris green.

The contrast between sprayed and unsprayed rows was marked. Flea beetles and tip burn (due to drought) were the chief troubles. There was no late blight. The potatoes were of the variety Green Mountain.

The expense account contained the following items:

325 lbs. copper sulphate @ 5½c.....	\$17 06
2 bbl. lime @ \$1.50.....	3 00
60 lbs. sal soda @ 1¼c.....	75
22 lbs. white arsenic @ 10c.....	2 20
50 hrs. labor for man @ 20c.....	10 00
50 hrs. labor for horse @ 10c.....	5 00
Wear of sprayer.....	5 00
Total.....	\$43 01

The test rows (510 ft. by 30 in.) yielded as follows:

One double-sprayed row, 182 lbs.= 103.4 bu. per acre.

One single-sprayed row, 158 lbs.= 89.9 bu. per acre.

One unsprayed row, 109 lbs.= 62 bu. per acre.

Gain from double-spraying, 41.4 bu. per acre.

Gain from single-spraying, 27.9 bu. per acre.

Potatoes being worth \$2 per barrel (= 69 cts. per bu.) at digging time, the gain of 27.9 bu. had a value of \$19.25. Subtracting the expense of single-spraying, \$2.87 per acre, we have left a *net profit of \$16.38 per acre.*

THE JAMESPORT EXPERIMENT.

Conducted by Henry A. Hallock, near Jamesport, Long Island. Sixteen acres of potatoes were sprayed four times. The sprayer used was a two-horse, four-row "Iron Age" sprayer carrying two nozzles per row. The dates of spraying were June 21, 29, July 13 and 20. The bordeaux was made by the 6-4-50 formula. The water was pumped by a gasoline engine and hauled from 40 to 100 rods. In the first two sprayings arsenite of soda was used with the bordeaux at the rate of four quarts of the stock solution to 50 gallons of bordeaux. There were four check rows. These received paris green twice — June 22 and 30. There appeared very little contrast between sprayed and unsprayed rows. Flea beetles and drought were the only troubles in this experiment.

The expense account contained the following items:

960 lbs. copper sulphate @ 4½c.....	\$43 20
450 lbs. lime @ 1c.....	4 50
160 lbs. sal soda @ 1½c.....	2 00
40 lbs. white arsenic @ 4½c.....	1 80
40 hrs. labor for man @ 20c.....	8 00
40 hrs. labor for team @ 20c.....	8 00
Wear on sprayer	5 00
Total.....	\$72 50

The test rows (684 x 3 ft.) showed the following yields:

Two double-sprayed rows, 977 lbs.=172.8 bu. per acre.

Two single-sprayed rows, 1,005 lbs.=177.8 bu. per acre.

Two unsprayed rows, 741 lbs.=131.6 bu. per acre.

Gain from double-spraying, 41.7 bu. per acre.

Gain from single-spraying, 46.7 bu. per acre. At digging time the market price of potatoes was 60 cents per bushel. At this price, 46.7 bu. have a value of \$28.02. After subtracting the expense of spraying, \$4.53 per acre, there remains a *net profit of \$23.49 per acre.*

THE SOUTHAMPTON EXPERIMENT.

Conducted by Lewis E. Downs, Southampton, Long Island. Seventy-six acres of potatoes were sprayed four times with a two-horse, six-row "Aroostook" sprayer carrying one nozzle per row. The dates of spraying were June 23, 30, July 6 and 14. Bordeaux of the 1-to-8 formula was used and water for making it had to be hauled from 40 to 160 rods. In the first two sprayings three quarts of arsenite of soda stock solution were added to each 50 gallons of bordeaux. There was a four-row check which was treated twice with paris green — June 24 and 30. Six rows on each side of the check were double-sprayed at each application. Neither flea beetles nor blight caused any damage. There seemed to be nothing to spray for in this experiment. Hence, it is not strange that there was no contrast in appearance between the sprayed rows and the check.

The items of expense were as follows:

1,824 lbs. copper sulphate @ 6c.....	\$109 44
1,824 lbs. lime @ 1c.....	18 24
800 lbs. sal soda @ 1c.....	8 00
200 lbs. white arsenic @ 5c.....	10 00
128 hrs. labor for man @ 20c.....	25 60
128 hrs. labor for team @ 20c.....	25 60
Wear on sprayer	10 00
Total.....	<u>\$206 88</u>

The test rows (551 ft. x 33 in.) yielded as follows:

Two double-sprayed rows, 464 lbs.= 111.2 bu. per acre.

Two single-sprayed rows, 604 lbs.= 144.7 bu. per acre.

Two check rows, 137.7 bu. per acre.

Loss from double-spraying, 26.5 bu. per acre.

Gain from single-spraying, 7 bu. per acre.

The reason for the low yield of the double-sprayed rows is not known, but it is improbable that the extra spraying was responsible.

The market price of potatoes being 55 cents per bu., seven bushels would be worth \$3.85. Deducting the expense of spraying, \$.72 per acre, there remains a *net profit* of \$1.13 per acre.

SUMMARY OF BUSINESS EXPERIMENTS IN 1910.

TABLE XXII.—SHOWING RESULTS OF BUSINESS EXPERIMENTS IN 1910.

EXPERIMENT.	Area sprayed.	Number of times sprayed.	Increase or decrease in yield per acre.	Total cost of spraying for acre.	Cost per acre for each spraying.	Net profit or loss per acre.
	<i>A.</i>		<i>Bu.</i>			
Jamesport.....	16	4	46.7	\$4 53	\$1 13	\$23 49
Glenhead.....	13	4	27.9	2 87	72	16 38
Andover.....	6	4	33 5	3 58	90	8 14
Lancaster.....	10	2	18 6	1 46	73	7 84
Greenwich.....	5.5	*4	42.1	5 76	1 44	6 87
Batavia.....	13	4	23.9	2 49	62	5 87
Albion.....	20	8	28.0	6 05	76	5 15
Chateaugay.....	18	†8	32.4	7 04	88	4 30
Southampton.....	76	4	7.0	2 72	68	1 13
Sterling Station.....	12	5-7	—0.9	4 28	68	—4 60
Plattsburgh.....	13	5	—5.3	5 28	1 06	—7 40
Elmira.....	16	2	—24.2	2 37	1 19	—14 47

* Test rows had two single and one double-spraying; balance of field, three single-sprayings.

† Four double-sprayings on test rows; balance of field, three single-sprayings.

*Average increase in yield per acre, 19.1 bushels.**Average net profit per acre, \$4.39.*

SUMMARY OF BUSINESS EXPERIMENTS, 1903-1910.

TABLE XXIII.—SHOWING RESULTS OF BUSINESS EXPERIMENTS, 1903-1910.

YEAR.	Number of experi- ments.	Total area sprayed.	Average increase in yield per acre.	Average total cost of spraying per acre.	Average cost per acre for each spraying.	Average net profit per acre.
		<i>A.</i>	<i>Bu.</i>			
1903.....	6	61.2	57.	\$4 98	\$1 07	\$23 47
1904.....	14	180	62.2	4 98	93	24 86
1905.....	13	160.7	46.5	4 25	98	20 04
1906.....	15	225.6	42.6	5 18	985	13 89
1907.....	14	152.75	36.8	5 90	1 18	17 07
1908.....	14	200.25	18.5	4 30	92	8 53
1909.....	12	203.14	24.4	4 15	835	9 55
1910.....	12	218.5	19.1	4 04	90	4 39

*Average increase in yield, for eight years, 38.4 bu. per acre.**Average net profit, for eight years, \$15.25 per acre.*

VOLUNTEER EXPERIMENTS.

In 1904 the Station began collecting and recording the results of potato-spraying experiments made by farmers in all parts of the State. As these experiments are carried out entirely by the farmers themselves we call them volunteer experiments. It is probable that, in some cases, the yields, expense of spraying and other data given for the volunteer experiments are not as accurate as are those given for the farmers' business experiments. Nevertheless, they are valuable. They supplement the regular business experiments. By bringing together the results of a large number of business experiments and volunteer experiments extending over several consecutive seasons the Station hopes to be able to answer definitely the question, Does it pay to spray potatoes in New York? We are under obligations to the many farmers who have assisted in this work and take this opportunity to express our appreciation of their services. The experiments are to be continued at least one year longer. All who spray potatoes with bordeaux mixture are requested to leave a few rows unsprayed in order that it may be determined how much the yield is increased by spraying. The product of unsprayed and sprayed rows adjacent should be *weighed or measured* and the length of the rows measured so that the yields may be accurately determined. We cannot use experiments in which the yields have been only estimated. Neither can we use experiments in which the application of poison to the unsprayed rows has been neglected.

In 1910 much difficulty was experienced in obtaining volunteer experiments. Owing to dry weather there was little blight and consequently small benefit resulted from spraying. Also, potatoes were cheap. Under such conditions farmers lose their interest in spraying experiments. Yet the results of experiments are quite as important in dry seasons as in wet ones. It is hoped that in 1911 the number of volunteer experiments may be larger.

The following table shows the principal results of the five volunteer experiments reported in 1910:

TABLE XXIV.—SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN 1910.

Experiment.	Location.	Name.	Area sprayed.	Times sprayed.	YIELD PER ACRE.		Gain per acre due to spraying.	Cost per acre each spraying.	Price of potatoes.	Kind of sprayer.
					Sprayed.	Not sprayed.				
1	Canton.....	H. E. Cook.....	A.	11	Bu.	Bu.	Bu.	Cts.	Cts.	8-row, 2-horse, Hallauer.
2	Byron.....	Thos. Roach....	4	3	247.6	128	119.6	85	40	4-row, 1-horse, Iron Age.
3	West Rush....	T. E. Martin....	7	3-7	321.3	*224.9	96.4	55	35	6-row, 2-horse, Brown.
4	Lancaster....	F. W. Handy....	18	19	328	255	68	53	50	4-row, 1-horse, Iron Age.
5	Prattsburgh..	C. E. Noble.....	11	4	245.5	213.5	32	60	40	4-row, 2-horse, Watson.
			2	4	209.7	186.4	23.3	45	40	

* Yield of rows sprayed three times. There were no unsprayed rows.

ADDITIONAL NOTES ON THE VOLUNTEER EXPERIMENTS IN 1910.

*Experiment No. 1.*⁷ This experiment was conducted on the farm of the New York State School of Agriculture, Canton, N. Y. The potatoes were in two fields and there was a check of six unsprayed rows in each field. In one field spraying increased the yield at the rate of 147.4 bu. per acre; in the other, 92 bu. per acre. The yields and gain given in Table XXIV are averages of the two tests. Considering that there was no blight or rot and that tip burn was the only foliage trouble fought the increase in yield due to spraying is remarkably large. It is worthy of note that the spraying was done very thoroughly. In eleven applications the total quantity of bordeaux used was 1,050 gallons per acre. It was applied under high pressure (75 to 100 lbs.). Dean Cook considers this important. The sprayer used was one which had been built for orchard work but was readily adapted to potato-spraying by arranging pipe and nozzles in the rear. The pumping was done by a small gasoline engine. Eight rows were covered at each passage. The expense for labor and bordeaux mixture amounted to \$9.39 per acre.

Experiment No. 2. In this experiment one acre was sprayed three times, five acres five times and one acre seven times. In Table XXIV, the figures (96.4 bu.) given as the "gain per acre

⁷ An account of this experiment has been published previously (Cook, H. E. and Sheahan, J. J. Circular of information of the New York State School of Agriculture at St. Lawrence University, Canton, N. Y. *University Bulletin*, Series 5, No. 2, pp. 91, 92. Apr. 1911).

due to spraying" in reality represent the difference between seven sprayings and three sprayings. There were no unsprayed rows. Rows sprayed five times outyielded rows sprayed three times by 32.1 bu. per acre. There were also marked differences in the appearance of the foliage. No rot appeared at digging time, but some was found after the potatoes were placed in storage.

Experiment No. 3. The total expense of spraying 18 acres was \$180, or \$10 per acre, the items being as follows:

1,775 lbs. copper sulphate @ 4½c less 1 per cent.....	\$79 08
Freight on copper sulphate.....	2 13
10 bbl. Ohio lime.....	10 00
Freight on lime.....	1 00
19 days labor @ \$4.....	76 00
Incidentals and wear on sprayer.....	11 79
Total.....	\$180 00

The total quantity of bordeaux used per acre was 819 4/9 gallons which is considerably less than Mr. Martin generally uses. The unsprayed rows were of lighter green color and died about eight days earlier than the remainder of the field. Potatoes being worth 50 cts. per bushel the net profit from spraying was \$24 per acre.

Experiment No. 4. The potatoes rotted some, but there was more rot on the unsprayed rows than on the sprayed ones.

Experiment No. 5. Tip burn was the chief trouble in this experiment. Spraying only partially checked it. Sprayed plants were of darker green color than unsprayed plants.

The items of expense were as follows:

Four hrs. labor for man and team @ 45c.....	\$1 80
Wear on sprayer.....	40
Bordeaux mixture.....	1 40
Total.....	\$3 60

SUMMARY OF VOLUNTEER EXPERIMENTS, 1904-1910.

The following table shows the results obtained in the volunteer experiments during the past seven years—1904 to 1910, inclusive:

TABLE XXV.—SHOWING RESULTS OF VOLUNTEER EXPERIMENTS, 1904-1910.

YEAR.	Number of experiments.	Total area sprayed.	Average gain per acre due to spraying.		Average market price per bushel of potatoes at digging time.
			Bu.	lbs.	Cts.
1904.....	41	4	58	28	43.5
1905.....	50	407	58	32	57.0
1906.....	62	598	53	6	44.5
1907.....	24	264	30	28	58
1908.....	11	74	66	18	66
1909.....	12	115	44	22	51
1910.....	5	218	68	—	45

Average gain for seven years (205 experiments), 54.3 bu. per acre.

POTATO TROUBLES IN NEW YORK IN 1910.

In the growing season of 1910, Long Island and the southern portion of the State suffered severely from drought. The northern, central and extreme western parts of the State fared somewhat better. On the whole the season was a dry one. The average total precipitation for the year was 37.26 inches, which is 2.56 inches less than the normal, but more than an inch greater than the average for 1909.⁸ After the middle of September showers became more frequent and kept the vines green until frost which, in some localities, occurred as late as October 12. The month of October, which is the digging season over most of the State, was warm and wet.

The leading troubles of potato foliage were flea beetle injury and tip burn. Both were prevalent and destructive. Early blight (*Alternaria solani*) occurred frequently, but was rarely destructive. Late blight (*Phytophthora infestans*) first came to our attention on September 19. In a few instances it caused some injury to the foliage, but in the vast majority of cases it came so late that no appreciable damage was done to the foliage and its presence was not noticed. Accordingly, many farmers were surprised at digging time to find their crop affected with rot. Others first observed the

⁸ New York Section of the Climatological Service of the Weather Bureau. Annual Summary 1910.

rot after the potatoes had been in storage a short time. Such experiences were common. Throughout western New York, particularly, the crop was quite generally more or less affected with rot. As the rot had, apparently, not been preceded by blight there arose a widespread suspicion that the rot was not the late blight rot. However, our observations indicate that nearly all of it was caused by the late blight fungus, *Phytophthora infestans*. When weather conditions are exceptionally favorable for rot, as they were last fall, a very little blight may result in a large amount of rot. In those cases in which the rot first appeared after the potatoes were placed in storage, the disease either had not made sufficient progress to be detected at digging time or else the infection occurred at digging time. Certainly, infection at digging time is possible if the tops have been affected with blight and are still partly green or recently killed by frost when the potatoes are dug. It is especially liable to occur if the soil is wet at digging time and the tubers stored while damp.

DIRECTIONS FOR SPRAYING.

In general, commence spraying when the plants are six to eight inches high and repeat the treatment at intervals of 10 to 14 days in order to keep the plants well covered with bordeaux throughout the season. During epidemics of blight it may be necessary to spray as often as once a week. Usually six applications will be required. The bordeaux should contain four pounds of copper sulphate to each 50 gallons in the first two sprayings and six pounds to 50 gallons in subsequent sprayings. Whenever bugs or flea beetles are plentiful add one or two pounds of paris green or two quarts of arsenite of soda stock solution to the quantity of bordeaux required to spray an acre.

Thoroughness of application is to be desired at all times, but is especially important when flea beetles are numerous or the weather favorable to blight. Using the same quantity of bordeaux, frequent light applications are likely to be more effective than heavier applications made at long intervals; e. g., when a

horse sprayer carrying but one nozzle per row is used, it is better to go over the plants once a week than to make a double-spraying once in two weeks. A good plan is to use one nozzle per row in the early sprayings and two nozzles per row in the later ones.

Those who wish to get along with three sprayings should postpone the first one until there is danger of injury from bugs or flea beetles and then spray thoroughly with bordeaux and poison. The other two sprayings should likewise be thorough and applied at such times as to keep the foliage protected as much as possible during the remainder of the season. In some seasons very satisfactory results may be obtained from three thorough sprayings.

A single-spraying is better than none and will usually be profitable, but more are better. Spraying may prove highly profitable even though the blight is only partially prevented. It is unsafe to postpone spraying until blight appears. Except, perhaps, on small areas, it does not pay to apply poison alone for bugs. When it is necessary to fight insects use bordeaux mixture and poison together.

For the best results, spraying should be continued as long as the plants live. It is a mistake to discontinue spraying because the weather is dry and no blight present. A late attack of blight may result in heavy loss from rot. As a rule, those who spray most obtain the largest net profit. There seems little danger of overdoing it.

A CONTRIBUTION TO THE LIFE-HISTORY, PARASITISM AND BIOLOGY OF BOTRYOSPHERIA RIBIS.*

J. G. GROSSENBACHER AND B. M. DUGGAR.

SUMMARY.

This fungus infects and kills young currant shoots about the time they have completed their elongation growth (about mid-summer). It causes older branches and parts of bushes to wilt throughout the summer, due to a further advance of the fungus from twigs or side-shoots infected during former seasons. The appearance of numerous brown-leaved, dead parts of bushes in a plantation doubtless leads fruit growers to call the disease a blight.

When this disease was first known, the organism producing it was regarded as a "sterile fungus," spores having been observed neither on currants nor in pure cultures. As a matter of fact, there is no spore form present when a branch wilts except sometimes at the point where the parasite entered. This investigation has shown, however, that three types of spores are developed on the host, although the fungus usually remains sterile in pure cultures.

When young shoots incompletely hardened are killed by new infections, the fungus usually develops its simplest spore-form on the withering tips. In early summer of the season following the blighting of bushes the dead stems exhibit numerous more or less complex, black, spore-bearing bodies broken through the outer bark. These bodies contain a second type of spore, and they commonly produce also a third type a little later.

Several fungi may appear saprophytically on the dead bushes. One of the most prevalent of the saprophytes (*Nectria cinnabarina*) has been erroneously considered the cause of the disease. As a result of the extensive inoculation experiments undertaken

*A reprint of Technical Bulletin No. 18, corrected. July, 1911.
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in this investigation, two facts require notice: (1) *Nectria cinnabarina* is not parasitic on currants; (2) associated with the causal species of *Botryosphaeria* there is a form of the fungus morphologically similar which seems usually to be a saprophyte. Early in 1908, while growing on a great variety of culture media, sub-cultures of the fungus obtained at different times from the pith of currant stems blighted during 1907, the parasitic form was easily distinguished from the closely related saprophytic associate by a physiological characteristic,—the pathogenic species producing a purplish-pink color on alkaline starch-paste.

Since the study of the life-history of this fungus shows that the spores are produced on dead stems and branches of the host from early to late summer, and since currants seem to be most commonly infected about mid-summer or a little later, it appears highly probable that the disease induced may be considerably checked or reduced by carefully pruning blighted plantations during the month of May, instead of practicing winter-pruning, as is at present customary. The prunings should be burned before the end of May, instead of allowing them to remain in heaps about a plantation throughout the summer.

INTRODUCTION.

A GENERAL VIEW OF BOTRYOSPHERIA BLIGHT AND OF ITS CAUSE.

This disease of currants is called a blight by fruit growers because apparently normal branches or even whole bushes die suddenly during summer and become conspicuous on account of their adhering, browned leaves. It seems to be most prevalent and destructive in the Hudson Valley about Milton, Marlboro and Highland, N. Y., but it was also found present in some currant-growing localities in other regions of the State. Although the disease seems to affect mainly the cultivated varieties of *Ribes vulgare* it has also been found on cultivated varieties of *R. nigrum* and *R. Grossularia*, and possibly it is more apparent on the varieties of *R. vulgare* only because they are grown much more extensively than the varieties of both the other species together.

This blight is induced by a pleomorphic fungus, a species of *Botryosphaeria*, which infects young shoots from mid- to late-summer, usually killing the distal ends, and remains dormant during the winter in such shoots. When the host resumes vegetation in spring the parasite also progresses basipetally, invading all woody structures encountered. As the season advances, normal branches and even the whole of main stems (when the fungus enters them by a lower side-branch), are blighted by the progress of the fungus. On the withering tips of shoots which, while still somewhat succulent, are killed by new infections or invaded by mycelium advancing from a former infection, *Macrophoma* fructifications usually develop. On the maturer parts of the host, killed by the further advance of the fungus, black, botryose stromata are developed in late summer and autumn and bear sporulating pycnidia and perithecia during the following summer.

HISTORICAL SUMMARY OF THE DISEASE.

Early observations.—As a result of the early preliminary observations on this disease and the causal organism, the parasitism of the fungus was made apparent, but none of the spore-forms was found, and the fungus was therefore called a “sterile fungus.”¹ The presence of *Nectria cinnabarina* on dead stems in diseased plantations and the apparent scarcity or absence of the fructifications of the causal fungus at certain times no doubt led to the view that the disease is due to *Nectria cinnabarina*.² Extensive inoculation experiments have definitely established the pathogenicity of the “sterile fungus” and more limited tests during two years have shown that neither *Nectria cinnabarina* nor its conidial *Tubercularia* is parasitic on *Ribes vulgare* when introduced into fresh wounds of the host.

1. D. G. Fairchild. Notes on a new and destructive disease of currant canes. *Bot. Gaz.* 16:262. 1891.

Rept. Sec. Agr. 1891:368-70. 1892.

F. C. Stewart and F. H. Blodgett. A fruit-disease survey of the Hudson Valley in 1899. N. Y. Agr. Expt. Sta. Bul. 167:292-4. 1899.

2. E. J. Durand. A disease of currant canes. N. Y. Cornell Expt. Sta. Bul. 125:23-38. 1897.

The present investigation was begun during the summer of 1900 and followed somewhat intermittently, with occasional visits to the infected localities of the Hudson Valley, until the latter part of 1901. It was taken up again in early summer of 1907 and continued with but a few short intermissions throughout the past four years. Observations made during the early period of this work indicated that the causal fungus produces black, botryose stromata which may contain both pycnidia and perithecia. Isolation cultures were made from the spores of these fruit-bodies, and a mycelium was obtained. Material from this first isolation was inoculated into healthy shoots, giving entirely negative results. Similar cultures obtained from a later isolation yielded a fair percentage of effective inoculations; while every inoculation made with mycelium isolated from a recently blighted stem proved effective. This difference in behavior was at the time wholly unexplainable. In the later more extended period of the investigation the same irregularity was encountered in the results of inoculation experiments; it was then shown, however, that there are two physiologically distinct fungi in this morphological species. Both forms are present on the bushes of a blighted plantation, yet only one of the forms is an active parasite.

Acknowledgments.— While many persons have given aid in one way or another during this investigation, special acknowledgment should be made to the following: G. G. Hedgcock, W. A. Orton, H. S. Reed, C. Thom and F. A. F. C. Went, for contributing cultures of chromogenic fungi; G. F. Atkinson, G. Lindau, P. A. Saccardo, C. L. Shear and R. Thaxter, for opinions on the validity of the genus *Botryosphaeria* and on the nomenclatorial autonomy of the secondary spore-forms of a pleomorphic fungus; J. B. S. Norton, for collections of currant stems bearing sporulating stromata of the blight fungus; E. Bartholomew for contributing a part of the type specimen of *Dothiorella ribicola* E. & B., and also for comparing the *Dothiorella*-form of the blight fungus with *Dothiorella ribicola*; and special thanks are due F. C. Stewart for making numerous collections in blighted plantations and for cultures of other chromogenic fungi.

A GENERAL DESCRIPTION OF THE FUNGUS AND OF THE DISEASE INDUCED.

AS OBSERVED IN DISEASED PLANTATIONS.

A brief yet complete description of this disease and of the different spore-forms of the fungus causing it cannot be given satisfactorily, since both fungus and disease undergo considerable changes during a growing season. Probably the best way to give a fair idea of the appearance and development of organism and disease is to follow them briefly throughout the growing season.

In April and May the shoots infected during the previous summer, of which a distal 0.5 — 4 dm. had died, were found to have small black stromata breaking through the periderm in more or less regular rows to within about a centimeter of the living bark. The shriveling distal tips of such shoots exhibit no stromata, although they often show slight sclerotic enlargements about the numerous old *Macrophoma pycnidia* which had been developed in them shortly after infection. The shoots which were killed by new infections after the hardening of the tissues often bear small stromata up to their tips. By the middle of May many pycnidia have developed *Dothiorella* spores, but the larger and often irregularly arranged stromata on parts of stems which had been killed by the further advance of the fungus were yet mostly immature. The stromata of the former type develop mostly or entirely pycnidia in early summer, although many of them produce perithecia later; those of the latter type usually contain a mixture of immature pycnidia and perithecia, and some only immature perithecia. However, during the latter part of May and early June many of the larger stromata were found to have sporulating *Dothiorella pycnidia* interspersed among immature perithecia, which developed ascospores a little later. But some stems that seemed to have been dead more than a year and bore somewhat weathered botryose, black stromata (which had evidently sporulated during the previous summer) were often found to have still some scattered perithecia and pycnidia intact containing viable spores in April, and even as late as May.

Nectria cinnabarina and a species of *Pleonectria* were commonly found more or less plentiful during spring and early summer in blighted currant plantations. They occurred usually on weathered, dead stems, although sometimes also on those which seemed to have died during the previous summer. In cases such as the last mentioned the pith in the basal ends of the dead stems was generally discolored, and *Botryosphaeria stromata* were usually found on the bark, indicating that blighting probably followed an invasion by the true parasite.

During the past four summers, about the middle of May or a little later, a small beetle (*Psenocerus supernotatus*) was always found present in blighted plantations, assiduously feeding on and completely eating up large numbers of *Botryosphaeria stromata*. See Plate XII. If examined in the latter part of May or early June large collections of botryose dead stems obtained in April and early May and stored in the laboratory may be found to have a number of these fungus-eating, or mycophagous, beetles feeding on the stromata. At the same time a number of the stems are found to possess borer holes. This goes to show that not only do these beetles feed on the stromata and spores but that the larval and pupal stages are passed in currant stems that have evidently died of *Botryosphaeria* blight. These stages in the life history of the borer are known,³ but the manner and place of oviposition have never been observed. The beetles are usually present in large numbers during June.

Bits of pith taken at intervals of about 6 mm., from shoots infected during the preceding summer, and transferred to series of potato-agar tubes showed that by the middle of April the average advance of the mycelium into normal-looking pith was about 2.2 cm. since winter; though the leaves of currants had only just begun to unfold. On repeating the test a month later the fungus was usually found to have progressed about 4-5 cm., but in many

3. A. Fitch. American currant borer. Trans. N. Y. St. Agrl. Soc. 16: 416-23. 1856.

A. J. Cook. American currant borer. Mich. Agrl. Expt. Sta. Ann. Rpt. 3:45. 1890.

instances much farther. In fact, in some cases where the distal 2-4 dm. of newly infected shoots had died during the previous season, the infected stems died to the ground by the latter part of May. As a result of such advances of the fungus, side-branches or main-stems encountered wilt or blight, and become conspicuous by adhering rusty-brown leaves. Sometimes when short, succulent side-branches are invaded by the advancing mycelium, *Macrophoma* pycnidia develop in great numbers on the withering part. See Plate VI. However, frequently large stems blight as a result of the resumption of vegetative activity by the fungus which, during the latter part of the preceding summer, had entered through a very short spur and killed a small area of bark and wood of the stem before further growth ceased. Such small cankerous regions were found to bear *Botryosphaeria stromata* from which coils of *Dothiorella* spores were often seen exuding in June and July. Even when winter pruning was most carefully done, leafless dead tips resulting from infection the previous summer are commonly present in blighted currant plantations in spring and early summer. Large branches and even whole bushes which died about the time natural defoliation occurs in autumn, or shortly after the leaves start in spring, are usually also conspicuous in such plantations during the latter part of April.

During July and August the blighting of large branches and bushes, resulting from the further progress of the fungus in infected plants, is very noticeable, especially in a dry season. In July many additional small cankers at different heights on various sized stems become evident as the parts of the host distal to them blight. The behavior of these cankered shoots indicates that the dormant fungus in some of the late-summer infections vegetates but little until mid-summer of the following season, though it *may have produced sporulating stromata* on the cankered areas. In late June and early July the *Dothiorella* type of spore is most prevalent, while the ascospores, comparatively few in early June, become numerous during the middle and latter part of July. Although the numerous small pits in the bark

of dead stems which had contained sporulating stromata of the fungus were very noticeable throughout July, the mycophagous *Psenocerus* was seldom seen in the early part and never during the latter part of the month. However, even many newly formed sclerotic masses which had developed under the periderm of stems and branches that had blighted during early summer were found eaten out, as shown on Plate XII.

It is in July that infections of young shoots become evident in large numbers, and although these new infections are inconspicuous as compared with the blighting of large branches, stems and whole bushes which are killed by the further progress of mycelium from a former infection, they are, nevertheless, the only kind of actual infections found. In blighting stems the fungus is present mainly in discolored stretches at the base of the blighted part, while it permeates throughout the discolored pith and other dying parts of newly infected shoots. The earliest evident stages of infection were seen during the first days of the month, as indicated by discolored, dying areas on shoot-tips while the leaves were usually still turgid. These early infections were commonly found only in older, much blighted plantations which had many dead stems bearing sporulating stromata. In young plantations showing no evident dead, stromatic stems, early infections were only rarely found, although later infections were often common. On July 3, 1909, a count was made of the newly-infected shoots occurring in sixteen rows of a blighted plantation in which many stroma-bearing stems were present. The rows were about 110 m. long and had on an average seven evidently infected shoots per row. One and two-year-old plantations located 20 to 50 m. to the south, east and west of the blighted one showed no infections at that time, although a month later some infected shoots were found in each of them. However, a thrifty three-year-old plantation a few meters to the southeast of the badly blighted one was found to have a few infections, but this also contained a few dead, spore-bearing stems. Usually additional new infections continue to become evident during July both in

blighted and in adjoining unblighted patches; so that by the end of July or during the first week of August these recently-infected and often more or less withered tips may be quite conspicuous. In 1908 most of the new infections became evident during the middle of July. However, those which became effective in the last week of July and early part of August are not so readily found and usually kill but a small part of the host. Late infections are less evident because currant shoots have become firm, and leaves invaded by the parasite are often shed soon after infection occurs, so that frequently, during the latter part of the infection period, the affected shoots may be located only by the absence of one or more leaves near the distal ends. In some cases the bark and wood, and often the pith about a leaf-scar, are found dead and discolored on removing the covering of primary cortex. In others only the leaf traces and the immediately surrounding tissues are discolored and contain the fungus. However, these later infections may often be located (during August) by dead, pendant, green laminæ on yellowish-green, living petioles, as may be seen on Plates III and IV. In some cases the leaf-traces entering the axis, parts of the surrounding bark and wood and sometimes even pith tissues were found discolored, while in other instances only a slight discoloration of the leaf-traces was noticeable and in some no discoloration was observed. Yet in large numbers of such petioles having no discoloration of the leaf traces the fungus was proved to be present by cultural methods used in making series + 7B, + 11C and + 12C. In a two-year-old currant plantation near Milton, N. Y., on August 21, 1908, all evident petiole infections were counted in 12 rows of about 170 bushes each. The total count was 193, averaging about 16 per row; but in only 42, or about 21 per ct., did the fungus seem to have entered the axis, as judged by discolored leaf-traces or other tissues. Some of these late-infected shoots become more or less enlarged about the point of infection early in the following season before death ensues.

The earliest infections seemed to occur just when active elongation of the shoots ceases and before the tissues become fully

hardened; for in practically all of the earlier infections the shoots shriveled and the leaves usually adhered tenaciously, while in infections becoming apparent later they never withered unless it happened to be a shoot which had a second elongation period and, therefore, a soft tip. Shoots appearing infected early in July usually died down from 1-3 dm., and generally developed numerous *Macrophoma* pycnidia on the withered tips, before the fungus became dormant; while those infested during middle and late July were not withered and had only the tips or a small region about an infected leaf-base killed, and, therefore, remain very inconspicuous and usually develop no *Macrophoma*. However, some such shoots as well as some normal looking ones were sometimes found to bear small sporulating *Macrophoma* pycnidia in the dead, primary cortex, but the starch-paste test showed that the fruiting bodies are those of some other fungus.

After the middle of August the majority of the sporulating stromata usually appeared considerably weathered, often with only a few scattered pycnidia and perithecia intact. They were frequently found cracked and broken. But the fruiting bodies which were still intact contained large quantities of viable spores.

Many stems and branches blighted in early summer were found to possess numerous, small, black, sclerotic bodies forming under the periderm, in July and August; and these become spore-bearing stromata the following summer.

August to October—During the latter part of August and September *Nectria cinnabarina* and a species of *Pleonectria* were usually the most conspicuous stromatic fungi in blighted plantations; but they were generally on weathered sticks, although sometimes also on stems the basal ends of which were yet living. However, in all but a few such cases as were carefully examined, *Botryosphaeria* stromata and a stretch of discolored pith were found adjoining the living parts, making it appear probable that the hypocreaceous fungi noted are only saprophytes.

During the latter part of September many of the weathered *Botryosphaeria* stromata having some intact perithecia, and often pycnidia, were sometimes found to bear one to several thin-walled

EXPLANATION OF PLATES.

PLATE II. BOTRYOSPHERIA RIBIS ON CURRANT.

Shoots of currant bush: With distal leaves injured by *Pœcil-ocapsus lineatus*, A; with tip blighted by early infection of *B. Ribis*, B.

Photographed July 14, 1909, near Milton, N. Y.

PLATE III. NEW INFECTIONS OF BOTRYOSPHERIA RIBIS ON CURRANT.

A, Near-terminal leaf; lamina curled and dry, petiole green but shown to be infected; B, shoot killed by natural infection; *Macrophoma pycnidia* near tip.

Photographed: A on August 3, 1909, near Milton, N. Y.; B, on July 22, 1909, in Geneva experimental patch.

PLATE IV. SEASONAL ANATOMIC CHANGES FAVORING INFECTION BY BOTRYOSPHERIA RIBIS.

A, Infected leaf at some distance from shoot-apex; B, longitudinal section of a shoot, petiole (1) and axillary bud, showing outgrown dying primary cortex (2) and cork layer (3) formed within it.

PLATE V. CONTRAST BETWEEN EARLY AND LATE INFECTIONS OF BOTRYOSPHERIA RIBIS.

A, Shoot infected early; conspicuous dead leaves adhere; B, shoots infected later in 1908, collected April 19, 1909, showing the covering primary cortex and buds on dead tips, with unfolding leaves on living parts.

B collected by F. C. Stewart, near Milton, N. Y.; photographed by G. T. French.

PLATE VI. BLIGHTED CURRANT BRANCH RESULTING FROM UNPRUNED INFECTION OF BOTRYOSPHERIA RIBIS.

1, Terminal shoot infected during preceding season (see Plate V); 2, its uppermost side branch killed by advance of fungus after dormant winter-period; branch shows numerous sporulating *Macrophoma pycnidia*; 3, second branch killed by advancing fungus.

Photographed July 20, 1909, near Milton, N. Y.

PLATE VII. CURRANT BUSHES AT GENEVA INOCULATED WITH BOTRYOSPHERIA RIBIS.

A, *Ribes nigrum* wound-inoculated with +2B, on July 3, 1908; B, *R. vulgare* wound-inoculated with +2A, on June 17, 1908. When photographed, June 18, 1909, leafless parts of both bore sporulating *Botryosphæria stromata*. A died within a month and B before end of summer.

PLATE VIII. FINAL STAGE OF CURRANTS BLIGHTED BY BOTRYOSPHERIA RIBIS.

A, Bush near Milton, N. Y., just after blighting of last living stems; B, bush in Geneva experimental patch a year after wound-inoculation with +A, at tagged point. Dead parts of both bear sporulating *Botryosphæria stromata*.

A photographed July 20, 1909; B, July 26, 1909.

PLATE IX. DIFFERENCES IN HABIT OF BOTRYOSPHERIA RIBIS.

A, Stem of *Ribes vulgare* with transversely ruptured periderm; B, smaller stem of *R. vulgare* with stromata arranged in longitudinal rows; C and D, stems of *R. Grossularia* with sporulating stromata, C having outgrown primary cortex yet adherent.

PLATE X. MAGNIFIED FRUITING BODIES OF BOTRYOSPHERIA RIBIS.

A, Longitudinally shriveled shoot-tip with primary cortex raised by numerous sporulating *Macrophoma pycnidia*; B, typical appearance of mature, somewhat top-shaped perithecia; C, stromata with typical mixture of immature perithecia and sporulating pycnidia.

PLATE XI. GENERAL MORPHOLOGY OF FRUCTIFICATIONS OF BOTRYOSPHERIA RIBIS.

1. Section of *Macrophoma pycnidium* in primary cortex with cork-layer incurved beneath; 2, rather large, practically single *Dothiorella pycnidium* from branch of bush inoculated with $+A_1$; 3, longitudinal section of normal shoot just after death of primary cortex (a), showing fully developed cork layer (b) and cortex (c); 4, *Dothiorella*-form spores, young and mature; 5, section of sporulating perithecium, from an inoculated plant; 6, typical ascus with eight spores (actual length about 85μ); 7, simple *Dothiorella* stroma broken through periderm of shoot from a green house plant inoculated with $+2A_1$; 8 to 12, sections of stromata; 8, from plant inoculated with $\pm A_1$; showing superficial and immersed pycnidia; 9, containing both pycnidia and perithecia (on left), from plant inoculated with $+A_1$; 10, showing superficial sporulating perithecia and an empty pycnidial cavity deeper in the stroma; 11, showing sporulating perithecia along raised margins of stroma and empty pycnidial cavities in depressed center; 12, containing micro-pycnidium closely oppressed to the perithecia of *Botryosphaeria Ribis*.

PLATE XII. CURRANT STEMS AND THE MYCOPHAGOUS PSENO CERUS.

A, *Psenocerus supernotatus* which eats sporulating stromata from blighted stems,—female, 6 mm. long ($\times$ about 3 diam.); B, shoot from which early sclerotic stages of stromata were eaten during late June or early July; C, shoot from which sporulating stromata were eaten during late May.

PLATE XIII. CURRANT SHOOTS INJURED BY INSECT PUNCTURES.

A, *Ribes nigrum* shoot-tips dead and shriveled by combined effect of numerous insect punctures and shading; B, *R. vulgare* shoot with bark removed at right below. These punctures and those on shoot in A are apparently made by the species of *Ormenis* shown above.



PLATE II.—BOTRYOSPHERIA RIBIS ON CURRANT.
(For detailed explanation, see p. 137.)



PLATE III.—NEW INFECTIONS OF *BOTRYOSPHERIA RIBIS* ON CURRANT.
(For detailed explanation, see p. 137.)

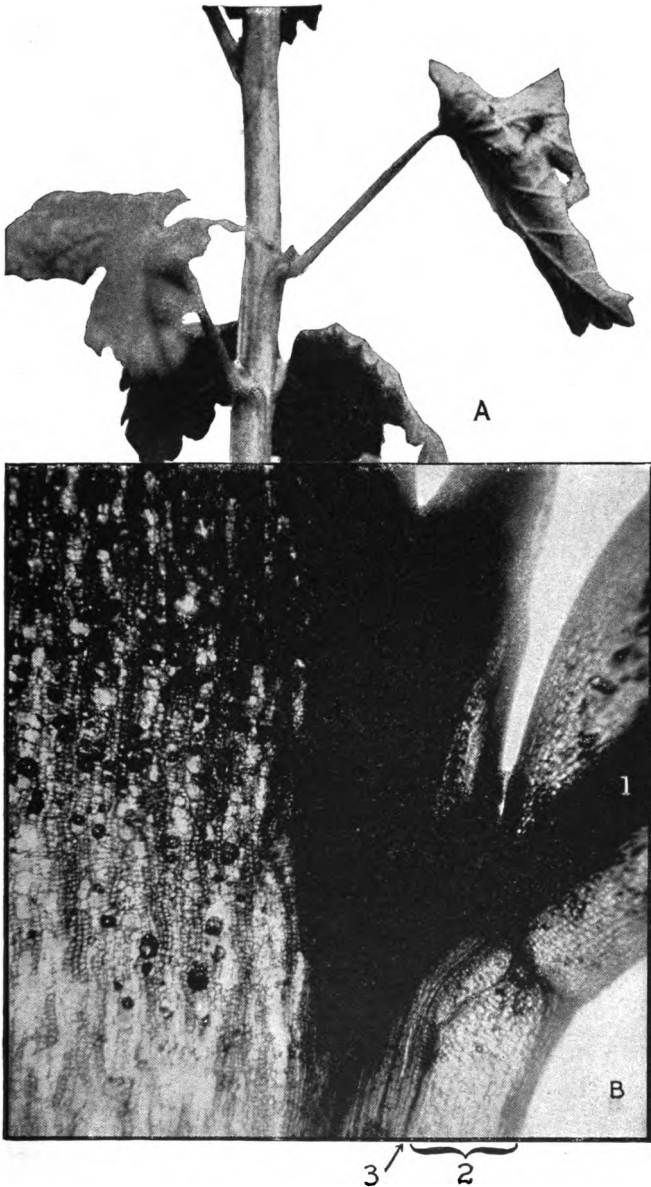


PLATE IV.—SEASONAL ANATOMIC CHANGES FAVORING INFECTION
OF *BOTRYOSPHERIA RIBIS*.
(For detailed explanation, see p. 137.)



**PLATE V.—CONTRAST BETWEEN EARLY AND LATE INFECTIONS
OF BOTRYOSPHERIA RIBIS.**
(For detailed explanation, see p. 137.)



PLATE VI.— BLIGHTED CURRANT BRANCH RESULTING FROM UNPRUNED
INFECTION OF *BOTRYOSPHERIA RIBIS*.
(For detailed explanation, see p. 137.)

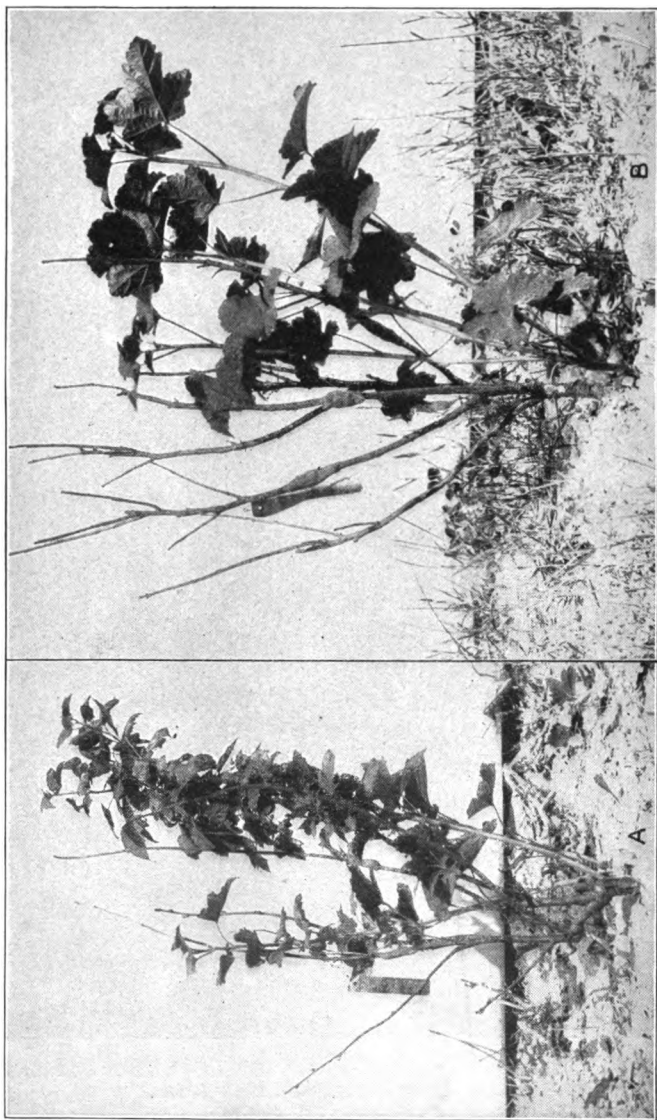


PLATE VII.—CURRANT BUSHES AT GENEVA INOCULATED WITH *BOTRYOSPHERIA KIBIS*.
(For detailed explanation, see p. 137.)

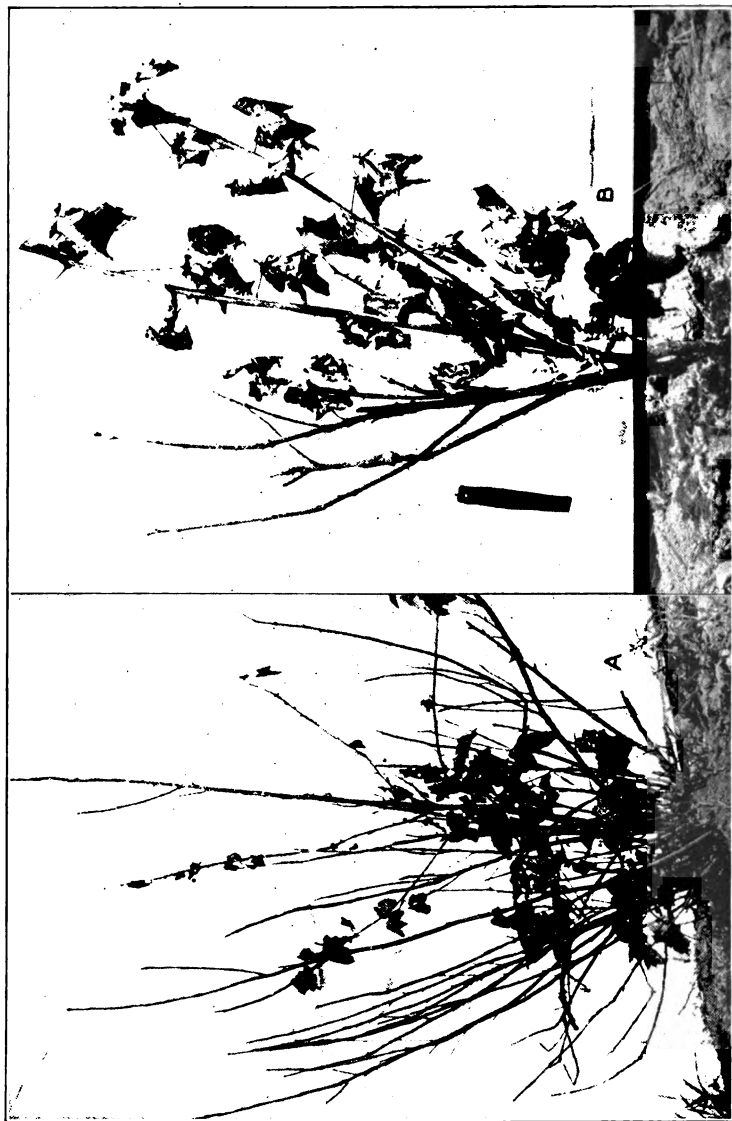


PLATE VIII.— FINAL STAGE OF CURRANT BUSHES BLIGHTED BY *BOTRYOSPHERA RIDIS*.
(For detailed explanation, see p. 137.)

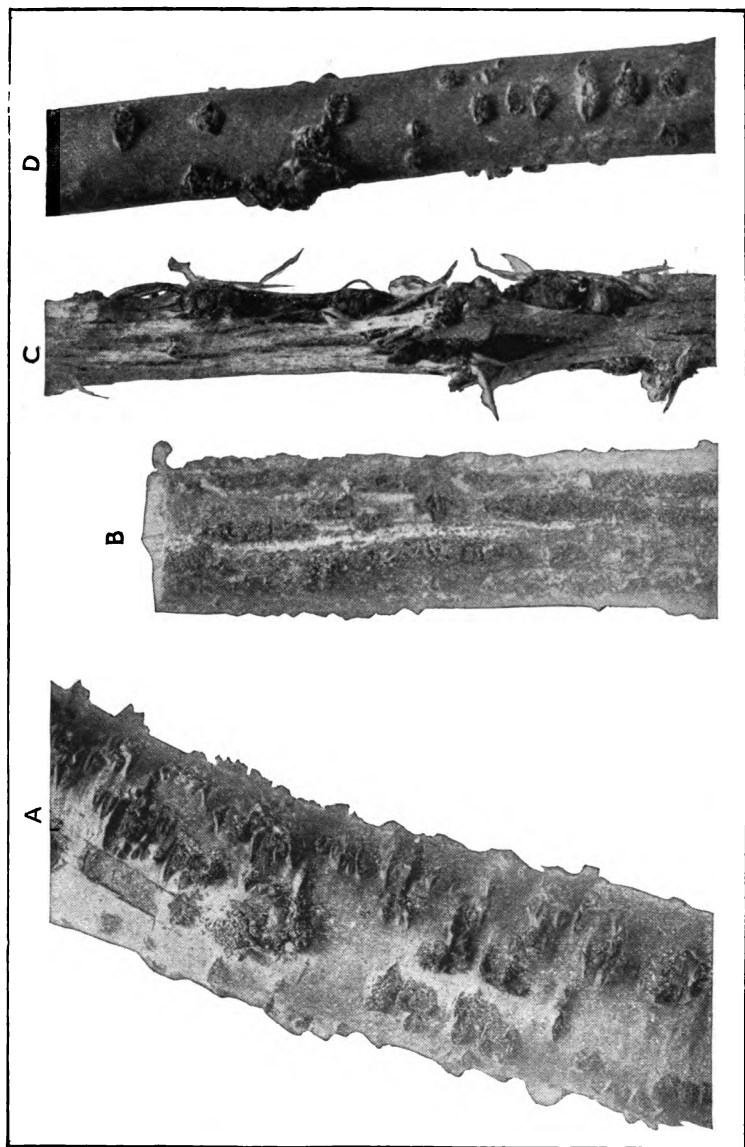


PLATE IX.—DIFFERENCES IN HABIT OF *BOTRYOSPHAERIA RIBIS*.
 (For detailed explanation, see p. 138.)

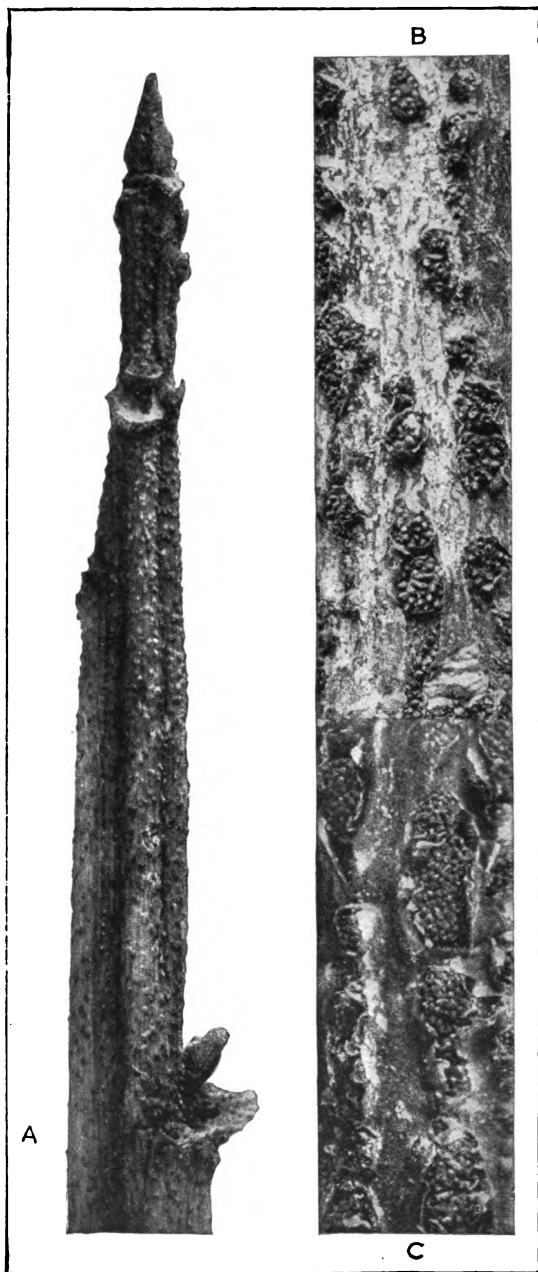


PLATE X.—MAGNIFIED FRUITING BODIES OF BOTRY-
OSPHAERIA RIBIS.
(For detailed explanation, see p. 138.)

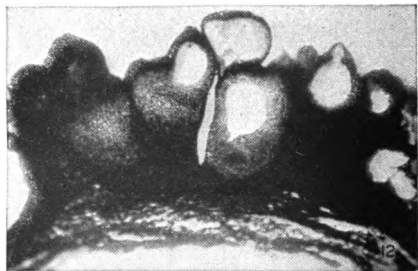
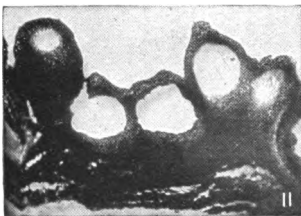
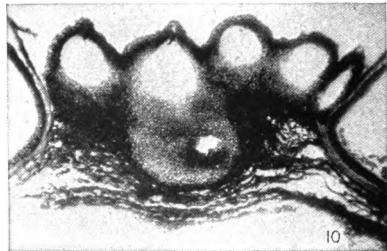
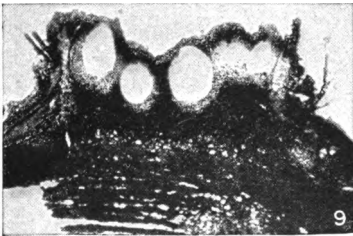
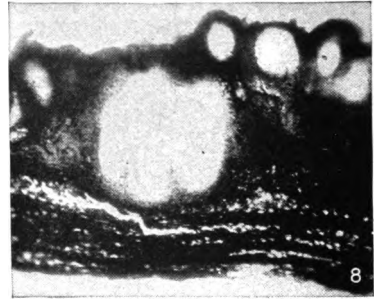
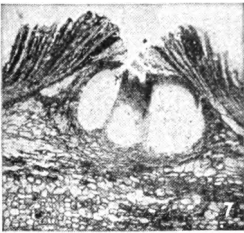
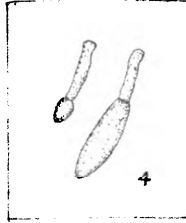
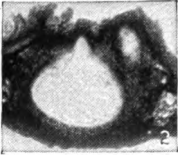
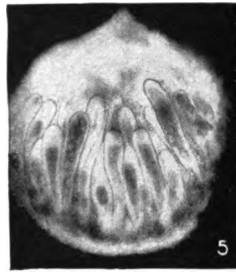
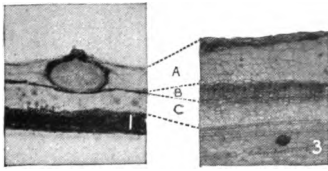


PLATE XI.—GENERAL MORPHOLOGY OF FRUCTIFICATIONS OF *BOTRYOSPHERIA RIBIS*.
(For detailed explanation, see p. 138.)

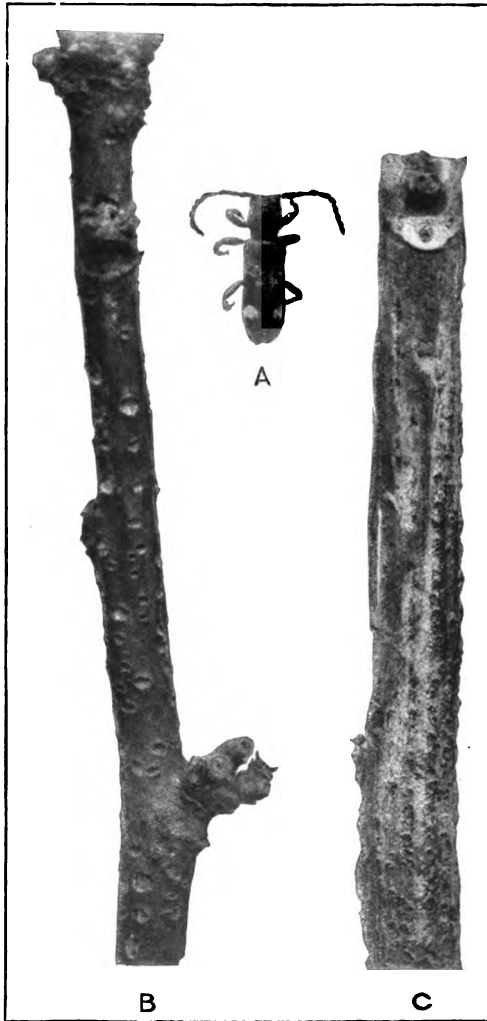


PLATE XII.—CURRANT STEMS AND THE
MYCOPHAGOUS *PSENOCERUS*.
(For detailed explanation, see p. 138.)

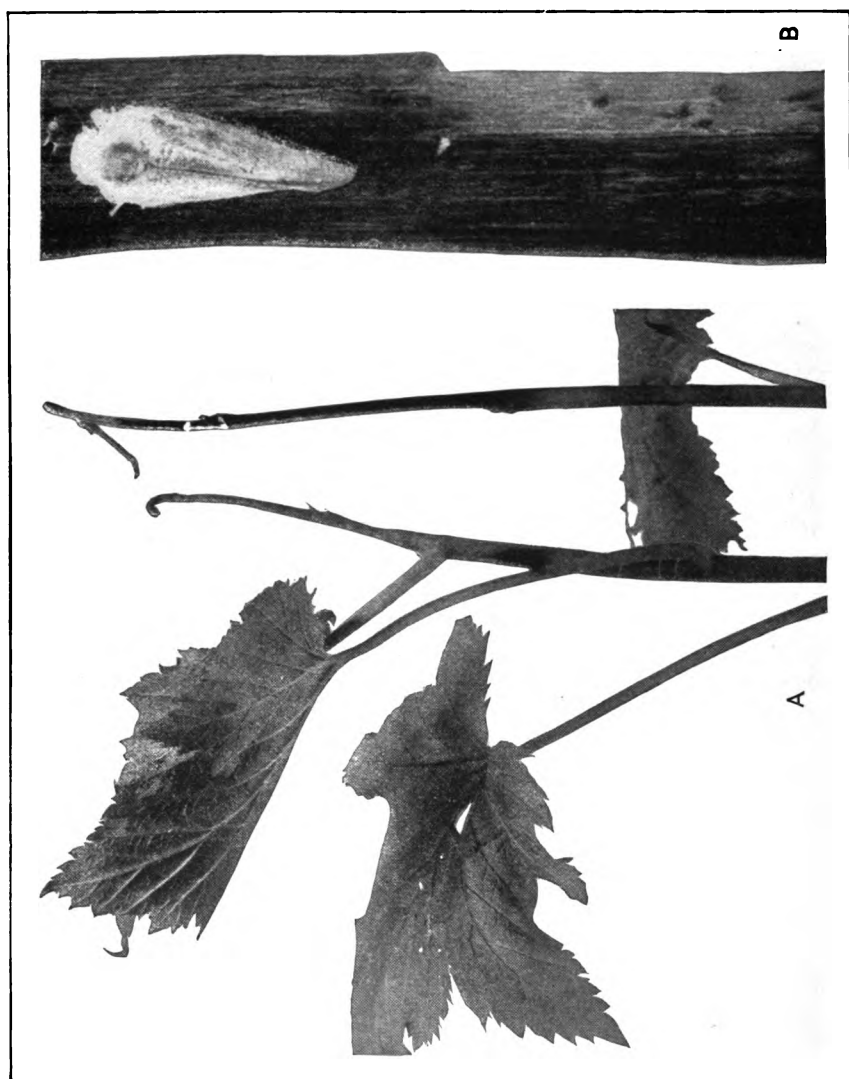


PLATE XIII.—CURRENT SHOOTS INJURED BY INSECT PUNCTURES.
(For detailed explanation, see p. 138.)

globular, scattered to cespitose pycnidia with small, porelike ostiola, and more or less convolute hymeneal surfaces bearing great quantities of very small, hyaline, cytosporoid spores. (See Plate XI, fig. 12.) Although they occurred sometimes in old perithecial cavities and closely fitting other depressions, the texture appears different from that of *Botryosphæria* pycnidia. The presence of very thin hyaline mycelium, ramifying through cracks and between the black stromatic hyphæ of *Botryosphæria* stromata, seems to indicate that these "microsporic pycnidia" do not belong in the life cycle of *Botryosphæria*. But it may be mentioned that the Tulasne Brothers described and figured a similar stage for their *Dothidia melanops*, now usually called *Botryosphæria melanops* (Tul.) Wint. These cytospora-like pycnidia, however, seem to belong to a fungus that develops on the disintegrating stromata of the *Ribes* fungus; although that point remains uncertain and could not be tested culturally because the spores failed to germinate. Yet it is possible that this only represents a virescence of certain intact portions of old *Botryosphæria* stromata.

AS OBSERVED IN THE EXPERIMENTAL PLANTATION AT GENEVA.

In order to check up field observations and experiments on the life history and parasitism of the fungus a small patch of one- and two-year-old currants was set on the Station farm at Geneva and about two dozen bushes in a greenhouse, early in the spring of 1908. These were mostly of the Cherry variety, but some of the variety Wilder were also included because this variety was reputed very resistant to blight. Since the disease seems not to occur in the vicinity of Geneva, inoculation experiments on these plants were deemed of more value than those made in an infested region, both from the standpoint of testing the pathogenicity of the fungus and for following its life history or the succession of its different spore-forms. The numerous inoculation experiments recorded in another part of this paper indicated that the varieties used were equally susceptible to wound-inoculations; and the further development of the parasite on the branches and bushes killed by it was in accord with the above field observations. Although the

Macrophoma-form was obtained in this manner only a few times, the *Dothiorella*-form was always produced on the stems in June of the year following death by inoculation; the ascospores also followed in their regular sequence and were contained in perithecia typically mixed with pycnidia. The succession of the spore-forms was the same whether the inoculation had been made with *Macrophoma*, *Dothiorella* or ascosporic material, and it is therefore assumed that the three spore-forms found succeeding each other on blighted bushes in diseased currant plantations and on those inoculated with the different forms of the fungus belong to the same organism, even though the spores were not obtained in artificial, pure cultures. The fungus-eating beetle was also present in the experimental patch in June, 1909 and 1910. A naturally-infected shoot bearing sporulating *Macrophoma* pycnidia was found there in 1909. See Plate III, fig. B.

A SUMMARY OF THE LIFE HISTORY AND DEVELOPMENT OF *BOTRYOSPHERIA RIBIS*.

The life history and development of *Botryosphaeria Ribis* is perhaps simpler when summarized apart from the disease it induces.

Simple form.—As stated before, the *Macrophoma* pycnidia are usually only produced on more or less succulent shoot-tips which die as a result of early infection, or on short, soft branches invaded and permeated by mycelium advancing through an infected axis. They develop just outside the forming cork layer which is then depressed by their growth. The primary cortex is raised to form marked protuberances on the outer surface of the shoot, and these are finally punctured by the short papillate ostiola through which the mature spores exude when moistened (Plate X, fig. A.) The pycnidia are depressed globular, and about $175\text{--}250\mu$ in width. The spores are fusoid, nonguttulate, continuous, hyaline, and measure $16\text{--}25 \times 4.5\text{--}7.5\mu$.

Stromatic form.—From mid-summer to autumn the *Dothiorella* stromata begin their development as small, globular sclerotic bodies

between the phellogen and outer cortical parenchyma of shoots and stems which had been killed by the fungus earlier in the season. The sclerotia become apparent externally as small, black spots over which the periderm is slightly raised. As they continue to increase in circumference and thickness the cortical parenchyma beneath is compressed and the periderm above, or outside, is raised until it finally bursts. The exposed outer surfaces of the stromata become roughened and finally botryose as the fruiting bodies develop within. The stromata which start during the earlier part of the above period develop mostly pycnidia, while those starting in late-summer and autumn produce mainly or even exclusively perithecia. During the following summer pycnosporos are formed in the pycnidial type of stromata in the latter part of May and June, but usually exude during the latter half of June and early July, while the ascospores develop during the middle and latter part of June and July. Many of the more slowly developing fruiting bodies about the periphery of typically pycnidial stromata, and sometimes a few in their more central parts, produce ascospores very soon after the pycnosporos mature. Some stromata which do not mature till the latter part of June and early July have sporulating pycnidia and perithecia interspersed in various proportions, while many of the stromata maturing during the latter part of July were found to contain only perithecia with no indication of the previous presence of pycnidia. The stromata of the early pycnidial type (which later produce some peripheral or scattered perithecia) were always found to have more or less numerous empty pycnidial cavities among or even under the sporulating perithecia, as shown in Plate XI, figs. 10 and 11. About the first of June it is often impossible to distinguish perithecial and pycnidial stromata (or the perithecia and pycnidia in a stroma) with an ordinary hand lens. When both types of fruiting bodies are mature they can usually be thus distinguished, because pycnidia extrude as globular or flat-topped bodies from the stroma, while perithecia are usually top-shaped extrusions with papillate ostiola. Yet sometimes only the ostiola project from the general surface of a stroma. (Plate X.)

The *stromata* are variable as to size and shape as well as in arrangement on the host. To fully appreciate this variability it is necessary to examine many specimens during different seasons of the year. However, the two extremes in arrangement may be seen on Plate IX. In one case the stromata are imbedded in the outer bark singly, or in irregular groups, usually rupturing the periderm transversely, and in the other they are arranged in longitudinal, more or less compact, rows, thus usually obliterating the manner of rupture. The longitudinally arranged stromata are confined mainly to stems and shoots that resulted from very rapid growth, which were not more than two years old at the time of death, while the more scattered arrangement is characteristic of the older and slow-grown stems. The early pycnidial stromata are usually small and contain comparatively few fruiting bodies while most of those maturing later develop a larger number. The early-fruiting stromata are generally rather thin, while the later ones are thicker and more pulvinate. The stromata are orbicular, or elongated, scattered irregularly, or arranged in more or less regular longitudinal rows. Their fruiting bodies give them a botryose appearance. The stromata measure from 0.5 to 4 mm. in diameter; most of them about 2 mm., but often 1-2 x 4 mm.

The *pycnidia* are from few to many in a stroma and generally measure from 175-250 μ in width. However, stromata bearing both asco- and pycnospores at the same time (heterosporous stromata) often contain from one to several pycnidia whose height or greatest diameter at right angles to the stromatic surface may be more than twice that of ordinary pycnidia though the width may not exceed that of ordinary ones. (Plate XI, fig. 8.)

The *perithecia* are borne in the same or in similar stromata and have the same widths as the common pycnidia; but they usually project more from the general stromatic surface and are more top-shaped than the latter. Frequently a more or less complete second tier of fruiting bodies is developed in stromata having the empty pycnidial cavities scattered between or beneath them in older parts of the stromata. See Plate XI, figs. 10 and 11.

The *pycnospores* are hyaline, fusoid, nonguttulate, continuous, and measure $18-31 \times 4.5-8\mu$. The asci are slightly clavate and measure $80-120 \times 17-20\mu$; the spores are continuous, hyaline, fusoid, $16-23 \times 5-7\mu$. The asci are interspersed by numerous filiform paraphyses.

FRUITLESS ATTEMPTS TO INDUCE SPORULATION IN PURE CULTURES.

In pure culture this organism has borne out remarkably well its earlier reputation as a "sterile fungus," although on the hosts three conspicuous spore-forms were subsequently obtained, two of which were found abundant in blighted plantations of the Hudson Valley during the earlier part of this investigation. Since that time the fungus has been grown on all of the solid media reputed to induce fruiting in culture, and many others; but only various irregular, woolly, stromatic bodies resulted, which in some cases developed perithecial bodies that never produced spores.

Interesting cultures were made in December, 1900, on tubed, sterilized currant-stems with transfers from material containing immature black stromata collected during the preceding month near Marlboro, N. Y. These were placed near a window, and after about a month there had occurred a considerable development of stromata from a few to six or more millimeters in diameter. They contained numerous perithecia which were sporulating considerably two months after the cultures were started. An attempt was made to discover qualitatively the essential requirements for the development of fruit by transferring the fungus from the above tubes to a dozen others and exposing them in duplicate to different temperatures and lights. Eight tubes were kept at room temperature and different lights; two receiving sunlight through water, two through potassium chromate solution, two through copper sulfate solution, and two in diffuse light. Two tubes were exposed to direct sunlight in a fairly cold room and two others were kept in the darkness of a thermostat at 28°C . After two months similar

abortive fructifications were present in all tubes but sporulation had occurred in none of them. It seems, therefore, that some unrecognized factor determined the development of spores in the first experiment.

Although many attempts were made some years later (1907-10) to duplicate that first successful experiment, only abortive stromata resulted which sometimes contained irregular cavities or condensed hyphal tangles as indicated above. No actual fruits with spores were since found in pure cultures except in some cases when portions of infected host tissues were transferred to tubes under aseptic conditions.

Since the fungus soon completely covers with a dense but fluffy mycelial mat sterilized currant-stems in a culture vessel to which it has been transferred, while in nature it vegetates wholly inside the host tissues, it seemed possible that the abundant aërial growth may hinder sporulation, or that its presence may indicate that the air in such vessels is too moist for the production of spores. In an endeavor to obviate the latter difficulty, living currant stems about 0.8 cm. in diameter and 35 cm. long were tightly wound with cords of twisted cotton at two points equally distant from the ends of the stems and from each other, so as to fit closely into a tube having an interior diameter of 2.5 cm. Stems so prepared were carefully inserted into culture tubes 40 cm. long, 2.5 cm. interior diameter, with a small side-neck about 2.5 cm. from the bottom. After pouring some water into the side-necks and closing these with rubber stoppers, and the ends of the tubes with cotton plugs, they were sterilized. The tubes were inoculated at the side-necks, half of them with the chromogen and the others with the nonchromogen. Three tubes were placed in a greenhouse in direct sunlight but with their lower ends shaded. Six were kept in the diffuse light of the laboratory. Twenty-five days after inoculation all tubes had abundant aërial mycelium though it was less copious in the upper compartments, especially of those in the sunlight. The usual sclerotic bodies had developed on the *outer* surface of the bark and in sunlight the aërial mycelium had a

rusty-yellow color. But no spores were present, nor could any be found in them a month later.

The presence, in diseased plants, of two physiologically different organisms which could not be separated by their morphological characteristics suggested the possibility that both forms must be present in the same culture in order that the fructifications develop to maturity. Therefore, transfers of a chromogen and a nonchromogen were made to separate points of the same flask of potato-agar. The cultures were combined in the following manner: $+8C_1$ and $-6B_3$, $+2A_1$ and $-5B_1$, $+7B_5$ and $-5B_1$, $+7B_5$ and $-6B_3$, $+8C_1$ and $-5B_1$, $+2A_1$ and $-B$, $+7B_5$ and $-B$, $+2A_1$ and $-6B_3$, $+8C_1$ and $-B$, the first member of each combination being a chromogen and the second a nonchromogen. Both transfers in each flask grew vigorously till their mycelia met and intermingled about midway between the transfers, and ceased further evident growth after covering the entire surface of the substratum just as when but one of them was used. The change of color with age and the development of irregular sclerotia also proceeded in the usual manner and without the production of spores.

While preparing culture-series $+11C$ (Page 161) it was found that sporulating *Macrophoma* pycnidia had developed on a number of the petioles from which the cultures were obtained by transferring the externally-sterilized petioles to tubes of potato-agar. In making culture-series $+12C$ a similar result was obtained, and a repetition of the experiment also yielded a high percentage of fruiting petiole-cultures.

However, though many attempts were made to obtain *Macrophoma* spores on uninfected petioles and young, soft shoots (some were sterilized in an autoclave and some with formalin) by growing the fungus from the different series on them, they all failed. Nor were spores developed on bits of wood from naturally infected stems that were transferred to tubes of potato-agar, but stromata formed earlier and in greater numbers in such cultures than in ordinary currant-stem cultures.

The fungus was also grown on potato-agar to which decoctions of chromogenic and of nonchromogenic cultures had been added, and on some which received decoctions of recently collected, dead currant-stems bearing numerous *Botryosphaeria stromata*; but only abortive stromata and no spores were developed. The growth in the decoction cultures was less than that on potato-agar checks, and the degree of retardation varied directly as the quantity of decoction used. The relative toxicity of uncooked extracts was not determined, for in view of the results obtained in cultures of infected wood tissues, it appeared unlikely that decoctions of old mycelia would induce sporulation. Some recently published work by Lutz⁴ on the re-use of culture solutions also indicates that sporulation varies with growth in a number of fungi.

It appears, therefore, that this chromogen and nonchromogen have no such relation to each other as that discovered by Blakeslee⁵ for some species of *Mucorineæ*; nor does their association in the same culture-vessels⁶ or growth on extracts of other cultures induce the development of spores.

Although these experiments have failed to induce sporulation it seems possible that if currant-stem cultures could be kept a year in such a way that the growth and dormant periods to which the fungus is subject in nature would occur, spores might be obtained in pure culture.

EXPERIMENTAL ATTEMPTS TO FIND THE RELATION OF THE VARIOUS SPORE-FORMS.

Many shoots about 3 dm. long which had died during the preceding season and bore numerous small, black stromata (some of which contained *Dothiorella* spores), were cut from young bushes of a blighted currant patch near Milton June 11, 1907, and stuck

4. O. Lutz. Über den einfluss gebrauchter Nährlösungen auf Keimung und Entwicklung einiger Schimmelpilze. *Ann. Mycol.* 7:91-133. 1909.

5. A. F. Blakeslee. Sexual reproduction in *Mucorineæ*. *Proc. Am. Acad.* 40:205-319. 1904.

6. F. D. Heald and V. W. Pool. The influence of chemical stimulation upon the production of perithecia by *Melanospora pampeana* Speg. *Nebr. Agrl. Expt. Sta. Ann. Rpt.* 22:130-32. 1909.

into pots of moist sand June 13; some out of doors, others in a greenhouse and some in a moist chamber. Five days after starting the experiment creamy white coils of spores were found to have exuded from all sticks in the moist chamber and from near the sand surface of a few of those in the greenhouse, but none had exuded from those left out of doors. However nearly two months later, following some wet weather, some exuded spore-coils were found near the sand on sticks left in the open.

During the latter part of November, 1907, about a dozen pieces of dead stems (like those from which culture-series —3A was obtained) having a few sporulating *Dothiorella* pycnidia in some of the smaller black stromata, were covered with wet sand for about three weeks. Then they were laid on the surface of the sand and kept moist under a bell-jar for several weeks, with the result that many stromata were found exuding ascospores. Unfortunately these pieces were stored in the laboratory without first being dried; and, when an effort was made the following March to obtain cultures from the material, most of the spores were found to have germinated and died. Nevertheless, scattered perithecia, still containing viable spores, were found, and from them the nonchromogenic series — B was obtained. (See p. 145.) Although this simple method seemed to afford a means of determining the relation of the different spore types found on blighted and dead currant-stems, it is too uncertain and may lead to the development of abnormal fruiting structures, for in the above experiment some stromata on the under side of the stems, and therefore supplied with an excess of moisture, produced long, tapering perithecia with rostrate ostiola. The blighted stems cannot be placed in an ordinary moist chamber, for it is well known that when material containing immature stages of a slow-growing fungus is put into such a chamber for further development molds usually appear and either vitiate or entirely prevent the desired results.

Since the addition of soluble salts to water decreases its vapor pressure, or evaporation tendency, it seemed that perhaps some saturated salt solutions (with an excess of salt) could be pre-

pared which when placed in a moist chamber would give the desired vapor pressure and therefore keep the enclosed air in the required state of moisture to permit the further development of such a fungus, and at the same time prevent the growth of weeds.

Large culture tubes about 5 cm. in diameter and 35 cm. long were fitted with rubber stoppers, each having five holes punched about half way through from the smaller end, such that short current stems could be inserted and thus suspended in the tubes from the inner side of the stopper, yet permitting an air-tight closure of the tubes. Since water has a vapor pressure of 17.4 mm. of mercury at 20° C. it seemed that possibly saturated solutions of sodium nitrate with a vapor pressure of 11.15 mm., potassium sulfate with a pressure of 14.4 mm. and potassium nitrate with a pressure of 15.0 mm. (at the same temperature) might range across the desired humidity.

Early in April, (1908) each of these three solutions was used separately in two tubes to the depth of about 3 cm. Five recently collected dead stems (cut too short to reach the solution) with numerous immature stromata were inserted into the holes in the smaller end of each stopper and thus suspended over the solutions in the tubes. In less than two months several molds were growing on the stems of every tube, although those containing the sodium nitrate seemed to have the least growth. Whether or not such a method can be perfected so as to be of practical value is doubtful. Further attempts with solutions of lower vapor pressure were not made because it was soon found that the fungus was developing both of the characteristic stromatic spore-forms on bushes inoculated during 1907.

However, since the *Macrophoma* form but rarely appears on inoculated shoots while commonly developing on naturally infected shoots the tissues of which were still immature and soft at the time of infection, the following experiment was devised to determine whether the usual *Dothiorella* type of fructification would follow under artificial conditions. Recently blighted, young shoots with numerous sporulating *Macrophoma* pycnidia about the

shriveled, dead tips were cut from bushes four or more cm. below the dead distal ends. The basal ends were recut under water and inserted into tightly-fitting short rubber tubes which were full of water. These tubes were then passed through holes in corks of salt-mouth bottles filled with water, thus giving the twigs and the fungus an abundant and near supply of water without surrounding them with an unusually moist atmosphere. Although the fungus generally vegetates little, or may remain dormant in such shoots until the following spring, the typical small *Dothiorella stromata* were found to have appeared two weeks later. Exuding coils of *Dothiorella* spores were also present. The chromogenic series +10B was made from them. (See p. 160.) The experiment was successfully repeated by simply allowing the freshly cut shoots with dead tips and living basal ends to protrude through holes in large cork stoppers and thick sheets of cork, floating on water in an open vessel.

THE TIME AND PLACE OF NATURAL INFECTION.

The stretching growth of fruiting plants of cultivated varieties of currants has usually ceased before the first of July; but young plants and scattered shoots of older bushes often exhibit a short secondary elongation period. When the primary cortex is outgrown, it becomes discolored and finally of a papery texture, the berries ripen, and the new shoots become hard. Most of the infection seems to occur during late June and July, for new infections usually become evident most numerous during the first half of July. From the inoculation experiments it appears that from six to fourteen days elapse before infections become apparent. The earliest infections evidently become effective before the tissues of shoot-tips are fully hardened, and the enclosing primary cortex is entirely functionless, because the distal 1-3 cm. of such shoots usually become more or less shriveled and often no cork layers could be found in them. (Plate XI, figs. 1 and 3.)

It was usually impossible to determine the manner and point of infection of the shoots dying during the last week of June and the

first few days of July, since such infections were often few and scattered; however from June 30 to July 3, 1909, and during early July, 1910, a sufficiently large number of early stages were found about Milton and Highland, N. Y., to localize them somewhat, although no entirely satisfactory explanation of the manner of infection was evident. In many of these cases a longitudinal wrinkling and discoloration was noticeable about a leaf-base sometimes from 1 to 3 cm. from the distal end, and sometimes a slight, concave curvature of the tip toward the infected side. The more distal leaves and tip of the axis were often still turgid and of a normal green color, while the involved leaf might exhibit a wilting lamina and a yellowish-green petiole. In some cases the infection seemed to have occurred at the very tip, and the discoloration involved the entire distal end, including the terminal bud; thus making it impossible to determine whether the infection occurred at the terminal bud, at the base of some petiole, or in some other way. In from a few to ten days after the first indication of these early infections, the terminal 4–20 cm. of such blighted shoots were dead and the distal ends had become shriveled and usually much roughened by numerous sporulating *Macrophoma* pycnidia. The attached brown leaves give the affected shoots a blighted appearance. The less conspicuous infections, becoming apparent after the tissues of the axis have become more or less hardened (often only resulting in the somewhat characteristic dying of one or more leaves and an area of bark, wood, and pith, about the leaf-base), proved more satisfactory in an endeavor to localize the point of infection, although it was impossible to determine with certainty the manner in which it occurred. These later infections seemed to take place mainly about the bases of petioles, and the earlier stages were usually made apparent either by a premature discoloration of the primary cortex at the abaxile side of the petiole, when the infection became evident before the whole primary cortex had become normally discolored throughout, or after the normal dying of the primary cortex by the wilting of seemingly uninjured laminæ when their

petioles were yet green or yellowish green. These petiole-infections were often numerous, although the percentage of successful infection of axes resulting from them seemed to decrease markedly during the latter half of July to practically *nil* by the middle of August. Although they continued to become evident, the leaves were usually shed early, thus warding off the infection of the host. A count made on August 21, 1908, indicated that in only about 21 per ct. of the cases in which infected leaves were found still attached had the fungus evidently entered the shoot; though it was proved present in the petioles by means of the starch test. It also appeared that the extent and degree of discoloration developing on an axis about the base of such a petiole decreased to an equal extent as the season advanced.

The shoots infected soon after hardening were frequently found to have completely dead, discolored, bark, wood and pith to the extent of a centimeter or more both above and below the infected node. In fact the distal portions of such shoots usually became defoliated and died before the end of the season, leaving short, leafless, dead tips which of course have normal looking covers of the primary cortex. During the latter part of July and early part of August these first-injuries decreased much in extent, so that they often consisted only of discolored leaf-traces. Some of the slighter nodal injuries which occur during late-summer consist of only a slight discoloration of the leaf-traces, thus leaving other stele-tissues apparently normal. Such injuries sometimes fail to extend during the next season, but in most of those in which the discoloration had also extended even to limited areas of surrounding bark, wood or deeper, the infecting fungus revives and resumes vegetation sooner or later during the following season, and as a result the stem involved blights. These lateral winter-dormant infections usually escape even the most careful observation after the leaves have fallen on account of the presence of a fairly uniform cover of dead, primary cortex on young shoots. See Plate V. However, up to the middle of August such petiole-infections are often readily located by the wilted laminæ, yet sometimes only by discolored leaf-scar regions.

In spite of the fact that most of both the early and late-season infections seemed to have taken place about the bases of petioles, early stages were sometimes found which had apparently occurred on internodes; in such cases the leaves of the adjoining nodes were found apparently normal and their leaf-traces were not discolored, yet the bark, wood and pith of a part of the internodal region were discolored and dead, and contained the fungus.

THE DISSEMINATION OF THE FUNGUS.

As stated before, the number of new infections in a blighted plantation was usually proportional to the number of dead stems and branches present during June. In adjoining young plantations in which apparently the disease was not present, the number of infections usually decreased directly as the distance from a diseased patch or from piles of unburned prunings increased. It has not been determined whether it is the wind, insects, or other agencies that are instrumental in the dissemination of the spores. The most striking case of dissemination observed during the past four years may be used to illustrate the rate and extent of infection from such a source. After mid-summer, 1907, all the bushes of a much blighted old plantation, near Milton, N. Y., were dug and piled along a stone fence. Early the following spring a new plantation was set out in a long strip of land along the south side of a thrifty, two-year-old plantation which is located about 100 meters to the north of and parallel with the stone fence. The new plantation contained about 35 rows of perhaps 175 bushes each, and extended to within about 45 meters of the fence along which the blighted bushes had been piled in 1907. After the middle of July, 1908, about 30 per ct. of these bushes were found to show from one to four of the shoot-tips blighted, most of them exhibiting sporulating pycnidia of the *Macrophoma* on the more or less shriveled tips. In the two-year-old plantation north of the new one and about 100 meters north of the fence, the conspicuous new infections (blighted tips with leaves attached) were counted in three groups of four rows each on July 31, with

the following result: The first group of four rows (about 100 m. from the fence) was found to have 115 blighted shoots. The second group taken, 8 rows to the north of the first group, had 44; and the third group taken, 8 rows to the north of the second and over 130 m. from the fence, 39. However, a count of the petiole-infections of these groups made on the following 21st of August did not give such a striking difference as regards the distance from the above stone-fence. The first or south group yielded 72, the second 62, and the third or north group 59. Although such observations seemed to indicate that the increase of the distance from sporulating material resulted in a decreased number of infections, many apparent exceptions were seen. More or less isolated new plantations which were apparently entirely free from infectious, dead stems, and isolated nursery patches where the cuttings are rooted, were usually found to become more or less infected during and after mid-summer. It seems plausible to assume that, since the cuttings are obtained from older bushes after the leaves have fallen, a few of them may contain some of the late-season, dormant infections which are not noticeable because of the uniformity of the dead cortical covering; and, further it may be assumed that the *Dothiorella* spores produced on such infections during the following June infect other plants around them.

In neither the local nor distant dissemination of the fungus from sporulating material have the agencies concerned been satisfactorily determined. In cases of the occurrence of new infections on shoots of a diseased bush with some dead stems bearing sporulation stromata, or of infections on bushes immediately surrounding diseased plants, it is usually assumed that air currents and insects are the disseminating agents. It seems possible, in fact, that these agencies may be sufficient to account for the distribution of the spores to greater distances. According to the tests made by Burrill and Barrett,⁷ the wind is very efficient in

7. T. J. Burrill and J. T. Barrett. Ear rots of corn. Ills. Agrl. Expt. Sta. Bul. 133:65-109. 1909.

disseminating spores even in cases where they exude in gelatinous coils, as do the pycnospores of *Botryosphæria Ribis*. The ascospores of this species are no doubt more readily carried by the wind, for at the ostiola they collect in little masses that soon become powdery and are thus more easily blown away. It is, therefore, a noteworthy fact that the pycnospores of this fungus were very numerous and the ascospores very few during the early and most important period of infection, while the ascospores were more numerous during the late infection period.

Only a few conspicuous insects that might be disseminating or inoculating agencies have been found commonly present in blighted plantations during the period in which new infections commonly occurred, but these insects may likewise be present in orchards in which no *Botryosphæria* blight was found. Among the insects that may be involved a species of *Ormenis*, *Pæcilocapsus lineatus*⁸ (four-lined leaf-bug) and *Psenocerus supernotatus* (American currant borer) were the principal species noticed during the past four years.

Upon most of the young shoots in some plantations there were found from a few to very many rather deep punctures which sometimes extended to the pith in *Ribes nigrum*. When such punctures were very numerous in *nigrum* shoots which were growing in the shaded parts of bushes, they often died and became more or less bent and twisted, as shown in Plate XIII. Usually only small, discolored traces of the punctures were left in *Ribes* wood; the wounds were overgrown at the peripheral ends, yet easily located during the remainder of the season by the small spots or depressions that could be seen on removing the bark, as shown in Plate XIII. The number of these punctures in a currant plantation seemed to vary directly as the number of adult *Ormenis* flies present during July, but it was not determined whether these flies made the punctures, although often as many as four to eight were seen on a shoot.

8. M. V. Slingerland. The four-lined leaf-bug. N. Y. Cornell Agrl. Expt. Sta. Bul. 58:207-39. 1893.

The adults of *Pæcilocapsus lineatus* were also present in blighted plantations during the latter part of June and first part of July. They not only feed by puncturing leaves (Plate II, fig. A) and shoots, but while ovipositing also cut longitudinal slits several millimeters long in the succulent parts of shoots.

Both of the above insects were equally numerous in plantations which were free from *Botryosphæria* blight, and the punctures could therefore only accidentally afford entrance for the fungus. In blighted patches many shoots with one or more oviposition-slits containing eggs were usually found blighted, many containing eggs were not diseased, and many showing no visible wounds of any kind were blighted.

Unfortunately some of the important facts about the life history and habits of *Psenocerus supernotatus* are unknown, for, since its imagines or adults feed freely on the stromata and spores of *Botryosphæria Ribis* from about the middle of May until July, this beetle may be of some importance both in the distribution and inoculation of the fungus. It seems to feed only on the sclerotia and stromata of *Botryosphæria Ribis* and on its nonchromogenic form. The beetle has neither been found eating other fungi nor present in plantations free of *Botryosphæria* blight, although of course it may feed on other things and therefore be present in blight-free plantations. Since the imago eats the fungus and the larva lives as a borer in the host, the beetle's habit of oviposition may have some relation to the dissemination of the fungus and the inoculation of the host. (See Plate XII.)

THE IMPORTANT CULTURE SERIES ISOLATED FROM THE HOSTS AND USED IN THIS INVESTIGATION.

Most of the original cultures were obtained by transferring bits of diseased or dead host tissues to culture tubes; however, several sets or series of cultures were made also from spores.

— 1900N. The first pure cultures used for inoculation purposes in the earlier period of this work, were secured November 7, 1900, partly from dilution cultures of rather immature stro-

mata on material recently collected near Marlboro, N. Y., and partly from tissue transfers from the interior of such material, under sterilization precautions. For convenience the cultures are designated as —1900N.

+1901M. Another set of cultures used in inoculation experiments, was made by transferring infected tissues of a dying currant stem which had been received from a correspondent, to a culture medium, with proper precautions. The set is designated for brevity in reference as +1901M.

±1901J. The last set of cultures isolated from the host during the earlier work, was made from dilution cultures of the *Dothiorella*-type of spores, (in July, 1901) which were very abundant in the stromata of old currant stems collected in the Hudson Valley during the latter part of June. The series is designated ±1901J.

±A. The first series of cultures used in the latter period of the work, was made by transferring bits of pith from stems collected near Milton, N. Y., June 13, 1907, to tubes of potato-agar. The bark was removed from the portion of stems to be used, and they were carefully split in halves without touching the split surface. Three bits of pith were transferred from the halves of each stem to as many tubes by means of forceps which had been flamed from 95 per ct. alcohol. A representative piece of each stem used was attached by a rubber band to the culture tubes originating as transfers from the pith of that piece. Four of the stems were of the preceding season's growth and had been cut from young bushes so as to include some of the living basal portions. The distal 3–4 dm. were dead and had small sporulating *Dothiorella* stromata breaking through the bark. The sets of transfers with the portions of stems from which they had been isolated were numbered A₁, A₂, A₃, and A₄. Four similar sets of three each were obtained from the pith of four large stems cut from diseased bushes which had evidently died during the preceding season. Large, botryose stromata contained some immature perithecia, often interspersed also with

sporulating *Dothiorella pycnidia*. The sets of tubes with their representative pieces of stems were labeled A_5 , A_6 , A_7 , and A_8 . Only A_1 to A_4 , and A_8 gave color on starch paste, and A_2 proved $+A_2$ till May 18, 1908, and after that always $-A_2$ while the other two stock cultures of that stem continued to react $+$ to the end of the investigation. They were therefore labeled $+A_1$, $\pm A_2$, $+A_3$, $+A_4$, $-A_5$, $-A_6$, $-A_7$, and $+A_8$.

$+2A$. A second series of cultures was similarly obtained from the much discolored pith of three seemingly recent infections (shoot-tips of currants), collected near Milton, N. Y., August 16, 1907. The three sets of threes were numbered $2A_1$, $2A_2$, and $2A_3$; but after the starch test $+2A_1$, $+2A_2$, $+2A_3$.

$-3A$. Another series of cultures was secured similarly from the pith of large, dead currant stems collected in blighted orchards near Milton, N. Y., November, 1907. The general appearance of the stems was like those from which the latter half of series $\pm A$ was obtained, except that they seemed to have died during the current season and have only stromata with immature perithecia. Each set of three cultures was accompanied by the corresponding stem as before. The series was numbered $3A_1$, $3A_2$, ... $3A_7$; and after the test $-3A_1$, $-3A_2$, etc.

$-B$. Series $-B$ was made March 13, 1908, from ascospores which had been obtained by keeping material like that from which series $-3A$ was secured, in wet sand under a bell-jar during about six weeks. The cultures were labeled B , B_1 , and B_2 ; but subsequently $-B$, $-B_1$, $-B_2$.

$+B_2$. On April 4, 1908, a set of cultures was made from coils of *Dothiorella* spores exuding from dead branches which had been inoculated with $\pm A_2$ on January 31, 1908. After the starch test the cultures were marked $+B_2$.

$\pm 2B$. Another series of cultures, consisting of five sets of eight tubes each, was made in May, 1908, from the pith of partially green stems exhibiting many, longitudinally arranged, botryose, erumpent stromata. The perithecia were immature, but some pycnidia with the typical *Dothiorella* spores were present in some of the stromata. The eight sets of three tubes each, after testing were numbered $+2B_1$, $+2B_2$, $-2B_3$, $+2B_4$, $+2B_5$, because only $2B_3$ proved nonchromogenic.

+3B. On August 3, 1908, a series of five sets of seven tubes each was made from the pith of five recently-infected shoots collected near Milton, N. Y., August 1, 1908. Numerous sporulating *Macrophoma* pycnidia had raised or broken through the primary cortex on the dead and more or less shriveled tips of the infected shoots. The sets were finally numbered +3B₁, +3B₂, ... +3B₅.

+4B. A corresponding series was then made from the above *Macrophoma* spores by crushing some of the pycnidia in a large drop of sterile water and transferring the spores to a dozen Van Tieghem cells with a platinum loop. In order to facilitate the transfer of germinated spores they were distributed to three points of the covers. Nine hours afterwards about 65–85 per ct. of them had germinated and some selected germinating spores from each cell were transferred to the lower ends of three potato-agar slants. On the third day mycelial transfers were taken from the upper part of the slant of a selected tube from each original cell-culture. The series was numbered +4B₁, +4B₂, etc., +4B₁₂ after growing its members on starch paste.

—5B, —6B. On August 4, 1908, a double series of spore cultures was made as above, from ascospores obtained from the typical black, botryose stromata on stems and branches of bushes which came from an old plantation that was so badly blighted that the whole of it was uprooted and piled during late summer of 1907. See p. 182. The stromata on most of the larger stems were scattered irregularly, and had generally ruptured the bark transversely, i. e., at right angles to the stem's long axis; while practically all smaller or younger branches possessed stromata arranged in more or less definite, narrow rows of considerable length, as may be seen on Plate IX, fig. B. The two types of fructification seemed identical in microscopic details.

Six cell-cultures were prepared, in the manner described for series +4B, from the spores of each type of stroma. Three hours after transferring the spores to the cells about 90 per ct. of them, both inside and outside of asci, had developed germ

tubes 40–95 μ in length. The series of cultures derived from the crosswise-rupturing stromata was labeled —5B₁, —5B₂, etc., —5B₆; while that obtained from the stromata arranged in rows was designated as —6B₁, —6B₂, etc., —6B₆ after testing them on starch.

+7B. An extensive series was also made from dying leaf-petioles which were either partly or entirely yellowish-green in color, and which had dried, but green-colored drooping, and often rolled, laminae attached. They were collected in blighted plantations near Milton, N. Y., August 21, 1908. Sixty such petioles were washed in large quantities of sterile tap water during about half an hour; half of them were then transferred to a fresh quantity of sterile water, and the other half to a .1 per ct. formalin solution, where some were left a quarter and others a half hour. Those remaining in the formalin solution half an hour were flamed while transferring them to sterile water, while the others were all transferred to fresh quantities of sterile water without flaming. The petioles were then transferred to as many tubes of potato-agar.

On the following day one or more mycelia had developed on all but the flamed petioles. Several of those merely washed in sterile water showed several fungi and bacteria, while all others, especially those having been in formalin solution but fifteen minutes, seemed to have developed a single type of mycelium. Transfers were made from ten such to fresh tubes of potato-agar and after testing were labeled +7B₁, +7B₂, etc., +7B₁₀.

—8B. A series of *Macrophoma* spore cultures was made from pycnidia on some leaf-petioles which had died following an inoculation in the leaf-axils. The dead petioles were collected August 25, 1908, and the cultures were made as above. The series was labeled —8B₁, —8B₂, —8B₃, etc., —8B₈, after the test.

—9B. On the same date another series was obtained from similar spores borne on dead petioles of shoots which had been inoculated with +A₈, +2A₂ and —B. After testing the tubes were labeled —9B₁, —9B₂, etc., —B₈.

+10B. Series +10B was prepared September 8, 1908, from coils of *Dothiorella* spores exuding from small botryose stromata which had developed on the thicker portions of shoots whose tips were found dead and roughened by *Macrophoma* pycnidia, August 1, 1908.

+C. Another series of cultures from ascospores was obtained April 22, 1909, from rather effuse botryose stromata on the basal portions of branches of a bush in the greenhouse which had been inoculated with $\pm A_2$ on April 28, 1908. The series proved chromogenic and was labeled +C₁, +C₂, etc., +C_n.

+2C. April 24, 1909, another series of pith transfers was made from shoots which had been infected during the previous season and had numerous small *Dothiorella* stromata on the dead parts. The series was designated +2C₁, +2C₂, etc., +2C₇.

+3C. An additional series of chromogenic cultures was secured from *Macrophoma* spores April 24, 1909, which had developed on shoot-tips inoculated with +A₄ June 17, 1908, in the Geneva patch. The series was named +3C₁, etc., +3C_n.

+4C. On May 17, 1909, series +4C₁, +4C₂, etc., was made from ascospores developed in rather effuse botryoid stromata near the base of a bush in the greenhouse that had died following an inoculation with +A₄, April 28, 1908.

—5C. Series —5C₁, —5C₂, . . . —5C_n was obtained May 19, 1909, from the pith of large, partly living stems bearing the typical botryose stromata containing immature perithecia and some pycnospores.

+6C. On the same date a set of cultures labeled +6C₁, +6₂, etc., +6C₇, was made from *Dothiorella* spores produced in large effuse botryose stromata in the bark of old stumps of bushes that had died to the ground during the preceding year, and had been cut off. The stromata also contained immature perithecia. The material was collected near Highland, N. Y. .

+7C. On May 29, 1909, the series +7C₁, +7C₂, +7C₃, and +7C₄ was isolated from the pith of *R. nigrum* branches, and +7C₅ from the pith of *R. vulagre* branches obtained in Rochester,

N. Y., and bearing the typical botryose stromata with sporulating pycnidia and immature perithecia.

+8C. From the pith of recently infected shoots of *R. vulgare*, collected near Milton, N. Y., July 2, 1909, the series +8C₁, +8C₂, etc., +8C₈, was secured.

±9C. This series was isolated from the pith of what seemed recently infected shoots of *R. Grossularia* collected in Rochester, July 14, 1909. Only +9C₄ and +9C₈ gave color on starch paste; the series was therefore labeled -9C₁, -9C₂, -9C₃, +9C₄ and +9C₈.

-10C. The series -10C was made on July 20, 1909, from *Macrophoma* spores borne in pycnidia in the discolored primary cortex of a normal looking currant shoot near Milton, N. Y.

+11C. On the same date the series +11C₁, etc., +11C₈ was made from yellowish-green leaf-petioles with shriveled, green blades. They were washed with sterile water, placed in a 1 per ct. formalin solution for fifteen minutes and then again washed in sterile water before transferring to potato-agar tubes. As it was several days before the transfers could be made from these tubes, the mycelia had completely covered the available surface. It was also found that sporulating *Macrophoma* pycnidia had developed on the petioles. The spores proved chromogenic.

+12C. A similar series from petioles was made August 3, 1909, and labeled +12C₁, +12C₂, etc., +12C₈. Again there was a development of sporulating *Macrophoma* pycnidia on the petioles.

The mycelia isolated during 1910 were simply tested for chromogenesis on alkaline starch-paste and discarded, since it had been found that pathogenicity and the development of color on starch paste are correlated.

SOME CULTURAL CHARACTERISTICS OF THE FUNGUS.

On beet or potato plugs, alfalfa or bean stems, potato-agar and various other solid media, as well as in plant decoctions the fungus grows luxuriantly, but most of the liquid synthetic media tried seem less favorable for its growth. Solid media with acid reaction are decidedly more conducive to growth than media which are neutral or alkaline. It has not been shown, however, whether it is the acid reaction of media that furthers the vegetative processes, or whether the presence of a base or the accumulation of alkaline by-products inhibits growth. In this connection it is well to note that litmus-potato-agar slants, made sufficiently acid to have a strong red color, are entirely changed to blue in about a week, by growing the fungus on them. On the other hand, the purplish, wine color of litmus-potato-agar (about +10 to +13 on Fuller's scale) is changed to a wine color instead of a blue. On otherwise suitable solid media, to which either too much acid or alkali had been added, the growth is, of course, retarded (within certain limits) according to the degree of excess; but the interesting fact is that the increase above normal acidity tends to a greater development of aërial mycelium, while its reduction below the normal, or alkalinity, tends to a reduced production of aërial mycelium, with a relatively more conspicuous growth in or on the substratum.

During a few days after transferring to natural potato-agar, the aërial mycelium develops as a loose, whitish colony about 5 mm. high, when a greyish color begins to develop about the transfer, and gradually spreads towards the growing periphery of the colony. This progressive darkening continues until by the time the whole of the available substratum has been covered by fungus growth the region to which the transfer had been made has become olivaceous; and in time the whole surface is olivaceous-black, although in some cases aërial tufts of an unusual height may yet be only dark grey. The transfers made directly from host tissues or

from *old, dormant*, dry cultures grow more vigorously and luxuriantly, and become olivaceous and darker earlier than do spore transfers or transfers from normally growing cultures. Growth was more luxuriant on potato-agar to which had been added malic or tannic acid, dihydrogen potassium phosphate (KH_2PO_4), peptone or asparagin than it was on the potato-agar alone; but it was less abundant on potato-agar to which hydrogen dipotassium phosphate (K_2HPO_4) had been added. A very good growth also developed on cotyledons of *Æsculus Hippocastanum*.

The fungus also grew on filter-paper (0.00008 gr. ash) moistened with distilled water, although very slowly and sparsely; it vegetated until all the available paper had been covered with a whitish-grey mycelium, then changed to a dark grey. The cultures were prepared as follows: Several paper circles were placed in each of a number of crystallizing dishes which were about 12 cm. in diameter, a similar but much smaller dish (50 cc. capacity) was inverted on the paper in each. After adding 45 cc. of distilled water to each crystallizing dish and covering each with a ground glass cover, all were sterilized. The transfers of mycelial masses were placed on the periphery of the papers. On account of the slowness of growth the inverted water-reservoirs proved a convenience.

Most of the general synthetic media in use proved to be unsuitable nutrient solutions for this fungus, and a better growth usually occurred when such solutions were used with agar-agar. But Czapek's medium as modified by Dox⁹ seemed to meet the requirements fairly well. However, as stated above, dihydrogen potassium phosphate was used instead of hydrogen dipotassium phosphate.

Chromogenesis.—The general cultural characteristics given above were the same for the mycelia of both the chromogenic and the non-chromogenic cultures, except that the former when in a

9. A. W. Dox. The intracellular enzymes of *Penicillium* and *Aspergillus*, with special reference to those of *Penicillium camemberti*. U. S. Dept. Agr., Bur. An. Ind. Bul. 120:1-70. 1910.

poor vegetative condition or in a practically nonpathogenic state, were always found to grow very meagerly even on the most suitable media, while no differences could be detected in the growth of the latter during their semi-pathogenic periods. The striking differences in the pathogenicity of the mycelia at different times become very apparent on consulting the inoculation records, especially the experiments made June 27 and August 16, 1907, May 6, June 23, July 3 and August 10, 1908, and June 28 and July 8, 1909. However, when both types of mycelia were in good vegetative condition the only constant distinction that could be made between them in cultures on liquid or solid media was the development of a purplish-pink color on neutral or alkaline starch-paste (or some highly starchy substance) by one and not by the other, when grown in daylight. When fresh potato-agar cultures were left in strong diffuse daylight the chromogenic mycelia usually developed pink color although its occurrence was somewhat inconstant. The addition of malic acid (+15 to +40 on Fuller's scale), peptone, or asparagin to potato-agar not only increased the growth of all mycelia as noted above, but also the formation of the pink color by the chromogen. When these media were made alkaline (—4 on Fuller's scale) growth was less than on ordinary potato-agar, and the pink color failed to develop. That is, the appearance and relative intensity of this color seemed to depend mainly upon the degree of metabolic activity, as is said to be characteristic of the pigmentation of certain animals.¹⁰

A similar pink color was also produced by the chromogen in some synthetic media when exposed to daylight. Sullivan's formula¹¹ F, although permitting comparatively slow growth, often gave a similar though transitory color. The medium given by Balls,¹² in which urea was substituted for Liebig's extract (reaction about —3 after sterilization) permitted even less growth,

10. C. W. Hargitt. Some unsolved problems of organic adaptation. *Proc. Amer. Assoc. Advanc. Sc.* 53:511-34. 1904.

11. M. X. Sullivan. Synthetic culture media and the biochemistry of bacterial pigments. *Jorn. Med. Research* 14:109-80(116). 1905.

12. W. L. Balls. Temperature and growth. *Ann. Bot.* 22:557-91(565). 1908.

but occasionally gave a slight pink color. The growth on Czapek's solution as modified by Dox, was fairly good and usually produced the pink color in cultures of the chromogenic form but the color became more intense and constant when dextrose was substituted for saccharose, while lactose permitted scarcely any growth, and gave no color.

After sterilizing this medium with maltose as the carbon source, the reaction was about +8 on Fuller's scale (phenolphthalein) but when the fungus had been grown in about 25 cc. of the solution eight days, its reaction was only about +1.5 (average of 5 titrations) for both types of mycelia, and a decided pink color had been developed by the chromogen. When dextrose was used the reaction of the medium before the introduction of the fungus, was +4, and eight days later only +0.5 (average of 4 titrations). The reduction of acidity in such liquid media was equally true of both mycelia, just as the growth on potato-agar resulted in the same reaction, as indicated by a litmus indicator. However, the appearance of this pink color was sometimes erratic, and therefore this medium has but little diagnostic value for this fungus. The pigment developed in these sugar solutions could not be bleached with hydrochloric acid, and for that reason it probably differed at least in form from the pigment produced on starch paste, for the latter is bleached on the addition of the acid.

On finding that starch paste may prove a differentiating medium, a very simple method of preparing it was developed. It was found that 15 grams of starch per 100 cc. of water, kept in fairly uniform suspension by frequent stirring or agitation, then distributed in about 20 cc. portions to 200 cc. Erlenmyer flasks by means of the large end of a 25cc. pipette, and finally sterilized in an autoclave at 120° C. gave a very satisfactory and uniform, jelly-like paste. Pastes of commercial corn, potato, and wheat starches were found as satisfactory and reliable as that of specially prepared starch, provided the required reaction obtained after sterilization. Corn starch was always used except for comparative tests, because it was most readily secured, and because it resisted hydrolysis at a higher degree of acidity than the others.

The fungous growth was always better on potato-agar than on starch paste, even when paste was given its optimum reaction (+4 to +8); and of course the more the reaction varied from the optimum the slower and more meager was the growth of the fungus; however, slight growth occurred even when the reaction was +20 or -20. The optimum reaction for growth did not coincide with that of greatest reliability for color formation; for although transfers from dormant stock cultures and from those in specially vigorous vegetative condition usually developed color after a few days on starch paste, with an initial acid reaction as high as +6, transfers from chromogenic cultures in rather poor vegetative condition often failed to develop the color on slightly acid paste while on neutral or slightly alkaline paste the color was always produced. Although the reaction most conducive to growth was between +4 and +8, neutral or alkaline paste proved the more reliable medium for the color test, probably because the alkalinity required for the development of this color was thus *provided*, so that even *slight vegetative* activity sufficed to produce it, as may be inferred from the fact that degrees of alkalinity nearly inhibitive to growth invariably gave the color. An initial reaction of +12 prevented the appearance of color although considerable growth occurred. Cultures on flour pastes of the common cereals and other starchy substances also gave rise to the same color when the required initial reaction was provided.

As stated before, daylight was found an essential factor in the chromogenesis of this fungus. The color was never obtained in cultures grown to maturity in a dark room, nor did any color develop in cultures exposed continuously at close range to three Welsbach lamps during several days and nights. However, such cultures developed a most brilliant color over the whole of their overgrown surfaces a few hours after exposure to daylight. After the mycelium had grown over a considerable part of a surface of paste which was too acid for chromogenesis, the color did not appear at once on the addition of an alkali, but was developed at the periphery of the colony a few hours after the addition, and never

appeared on the older growth as it did in the cultures in which chromogenesis had been prevented by keeping them in a dark room. The metabolic by-products giving rise to the color in alkaline paste, seemed to have become permanent leuco-bodies in the interior of the colony before the reaction was changed. The addition of one of a number of acids to young starch-paste cultures having a rich purplish color (before the older parts of colonies have become the rusty-brown color of age) causes the color to disappear gradually, but the older, rusty-brown phase of the color seems but little affected by acids.

Composition of starch.—Meyer's¹³ researches indicate that ordinary starch-grains are laminated or striated spherocrystals, composed of alternating layers of densely and loosely arranged radiating trichites which consist of amylose, in two degrees of hydration, and amyloextrin. His b-amylose and amyloextrin are soluble in boiling water, while his a-amylose or amylose-anhydride is insoluble in water except when heated as high as 140° C. The denser, thicker layers of a grain, which he suggests are formed during periods of relatively high concentration of the starch-forming substances in cells, are thought to be composed mostly of a-amylose trichites while the thinner, looser layers are made up of b-amylose and amyloextrin trichites. But according to Kraemer¹⁴ reserve starch grains are a polymerization product of sugars with an abstraction of water and consist of two crystalloidal (starch-cellulose and granulose) and a colloidal substance; the layers of the latter are said to have an especial avidity for aniline stains while those of the former stain blue with dilute iodine solutions. However, Fouard¹⁵ concludes, from his extended studies and experiments that starch is a homogeneous substance, capable of complete physical solution. On the other hand the work of Maquenne and

13. A. Meyer. Untersuchungen über die Stärkekörner. Jena. 1895. pp. 334.

14. H. Kraemer. The structure of the starch grain. *Bot. Gaz.* 34:341-54. 1902.

15. E. Fouard. Über die kolloidalen eigenschaften der Stärke und die Einheitlichkeit ihrer Beschaffenheit. *Jahreshr. Agrl. Chem.* 3. Folge, 11:483. 1908.

Roux,¹⁶ Gatin-Gruzevska,¹⁷ and others seems to indicate that the denser layers of a potato starch-grain consist of an insoluble amylopectin, (a glycogenous body) and the less dense layers of a group of soluble amyloses. It seems probable that this diversity in conclusions regarding the composition of starch is mainly due to the differences in the methods employed; and it appears that Meyer's method in studying its composition in relation to the formation and structure of its grains would prove more profitable than the mere study of its empirical composition. At any rate, the conclusions of Meyer and Fouard seem more in accord with the reactions in these cultures; that is, starch seems to be a homogeneous body as far as its cultural value and chromogenic properties are concerned. Cultures of the chromogenic fungus on the two constituents that Gatin-Gruzevska's methods are said to separate resulted in the development of the characteristic purplish-pink color on both.

SOME OTHER FUNGI TESTED ON ALKALINE STARCH-PASTE.

Among the fungi transferred to alkaline starch-paste the following failed to grow: A Botrytis from decaying lettuce, an Eurotium from dead currant stems, *Fusarium oxysporum*, a Penicillium found growing on normal malic acid, *Rhizopus nigricans* and *Valsa Pini*.

The following made some growth although often meager and constantly nonchromogenic: an Alternaria from a decaying pear and one from dead currant stems, a Botrytis from leaves, fruits, and dying shoots of currants, a Haplosporella from dead currant stems, *Macrophoma hyalina*, *Mycosphærella citrulina*, *Nectria cinnabarina*, *Penicillium peniophilum*, a Periconia from dead currant stems, a Rhizoctonia from Dianthus, *Sporotrichum Poæ*, a fungus found parasitizing shoots of *Ribes Grossularia*

16. Maquenne and Roux. Recherches sur l'amidon et sa saccharification diastasique. *Ann. Chem. et Phys.* 8 ser. 9:179-220. 1906.

17. Z. Gatin-Gruzevska. Über die Zusammensetzung des Stärkekorns. *Jahresbr. Agr. Chem.* 3. Folge 11:480. 1908. *Zentralbl. Agr. Chem.* 38: 200-03. 1909.

after they had been mined by the larvæ of the moth, *Opostega nonstrigella*,¹⁸ and one causing a rot of asparagus sprouts.

Monilia sitophila developed a very sparse growth and a pale salmon color, and *Neocosmospora vasinfecta* produced a considerably better growth and a rose-salmon color on the paste. An unknown fungus obtained through the kindness of J. K. Wilson of this Station, who found it as a contamination in cultures of milk bacteria, developed a color which seemed identical with that of *Botryosphaeria Ribis*. However, when the paste was made more than seven degrees acid a light yellow color was produced. It seems therefore that alkaline starch-paste is a convenient medium not only for distinguishing the *Ribes* blight fungus from its nonchromogenic form but is probably also of use in determining whether or not a recent collection of diseased or dead *Ribes* material was injured by *Botryosphaeria Ribis* by simply dropping pieces of the material into flasks of alkaline paste. This method of identification was often used during the latter part of this work with material from this and other States; it is especially convenient when neither stromata nor spores are present on the specimens.

GERMINATION OF THE SPORES.

The *Macrophoma* spores from fresh material always germinated freely in tap or distilled water, or in nutrient media in 8-18 hours, and from material left in the field over winter (nine months) about 60 per ct. germinated in 24 hours. But from similar material kept in the laboratory during the same time only about 10 per ct. grew, and none proved viable from such material after being stored in the laboratory one and a half years.

The *Dothiorella* spores germinated equally as well and proved as resistant as the *Macrophoma* spores, although in some cases they required a few hours longer for germination. The ascospores reacted similarly; however on one occasion in a large series of the nonchromogenic type in drop cultures of sterile tap water about 65 per ct. had germinated in three hours. (See p. 146.)

18. J. G. Grossenbacher. Medullary spots: a contribution to the life history of some cambium miners. N. Y. St. Agrl. Expt. Sta. Bul. 15:49-65. 1910.

INOCULATION EXPERIMENTS.

SPORE INOCULATIONS.

On June 18, 1907, a number of currant bushes near Milton, N. Y., were inoculated in shoots produced the previous season, and others in the spring growth by placing coils of *Dothiorella* spores (exuded from small stromata in the lower, dead, portion of a stem whose terminal 3 dm. seemed to have died during 1906) into wounds made with a sterile knife, by cutting short tangential slits and then carefully pressing the sliver of bark back again to retard evaporation. Four checks were prepared in the same way except that no spores were introduced. No infection was evident on October 7 (1907), and normal callus was found to have been formed about all of the wounds examined.

On July 2, 1907, a half dozen shoots of each of two bushes in the Geneva patch were inoculated with *Dothiorella* spores suspended in sterilized water, by diffusing a dozen spore-coils which had exuded from stromatic shoots in a moist chamber into water and transferring drops of the suspension to wounds made in the bark — these wounds being then covered with grafting wax. Several drops of the suspension were also placed on the tips of each of five uninjured growing shoots on another bush and left unprotected. There had been a slow, forty-hour rain and the day remained cloudy. Three months later no infection was evident, but after two years two of the wound-inoculated shoots were found wilted, and examination showed them to have dead, dry regions of fifteen or more millimeters in extent about the old inoculations, and these dead areas contained the usual stromata.

Coils of *Dothiorella* spores, exuding from small stromata in a canker on a recently wilted stem, were bound tightly against the bark of eight shoots on July 19, 1907, with thin ropes of green grass. No infection resulted.

On May 18, 1908, funnel-shaped cups were made about leaf-axiles on one each of two dozen shoots by enclosing the axis and

petiole in a band of grafting wax. Large ascogenous stromata containing numerous viable spores were taken from typically blighted stems (Milton, May 1, 1908) and placed into the cups which were then sealed by compressing the open ends about the included axis and petiole. About a month later the shoots apparently had not been infected, but several of the leaves, parts of whose petioles were inclosed by the wax cups, had died, and *Macrophoma* pycnidia were present on these petioles. Series —8B was made from this fungus.

Seven inoculations were made on young shoots in the greenhouse June 16, 1908, by introducing coils of *Dothiorella* spores, which had exuded from a bush killed after wound inoculating it with +2A₁ (January 31, 1900). The inoculated wounds were wrapped with sterilized moist cotton and covered with grafting wax.—Three months later four of the shoots had died.

In late summer (8-5-'08) the two types of ascogenous stromata (exuding spores) used to make the culture series +4B and —5B were placed in the axiles of leaves in the Geneva patch during a rainy, cloudy day and left unprotected. The large, scattered stromata from large stems were laid into each of three leaf-axiles of four other plants after first puncturing the adjoining bark of the axes with the point of a scalpel. The other type of stromata was used similarly on a like number of plants. No infection occurred.

In the Geneva patch, grafting wax cups were made about a near-terminal leaf-axile on each of three shoots of six bushes of the variety Cherry, on three shoots of each of four Wilders and on each of three shoots of two plants of *R. nigrum* (August 8, 1908). Several drops of sterilized water containing large numbers of ascospores, obtained from the above described stromata, were run into each cup and the cups left open. Four days afterwards a similar suspension was introduced into each cup and sealed in. No infection was found to follow, although in a few cases slight discoloration seemed to have been produced.

On September 5, drops of the above type of spore-suspension

were put on most of the leaves of three bushes in a greenhouse. The drops placed at the junction of laminae and petioles adhered better than those on any other portion of the leaves. One plant was put into a moist chamber and shaded from direct sunlight, and two shoots of another one were enclosed in large paper bags. No infection followed.

The numerous *Macrophoma* pycnidia on dead shriveled shoot-tips, killed during late summer of 1908 by new infections and collected August 26, 1908, were found still to contain great quantities of viable spores. On February 4, 1909, drops of sterilized water heavily charged with these spores were placed in profusion upon the emerging leaves and shoot-tips of four bushes in a greenhouse; but no infection occurred. Two weeks after the above date a like spore suspension from the same source was liberally applied to the leaves, petioles and leaf-axils of a bush in the greenhouse, and the application repeated three times during the same day. There was no evidence of infection two months later.

On the 8th of the following month two plants in the same house were given a like treatment using unsterilized water. One of the bushes was placed inside a moist chamber, but the effort was entirely ineffective.

March 18 a bush (in the same house) was given a thorough treatment with a *Macrophoma* spore-suspension from the above source in sterilized water, and to another bush a similar treatment with an ascospore suspension from the material used above. The treatments were repeated a month later. No evidence of infection could be found.

On May 17, 1909, the leaves and leaf-axils of two bushes (same place) were treated with a spore suspension made up in sterilized water from the same material from which culture series +4C was obtained. No infection developed.

July 6, 1909, bits of bark thickly set with *Macrophoma* were bound against young shoots just below petiole bases, with moist absorbent cotton and covered with melted paraffin to prevent drying out. The bits of bark were obtained from recently infected

shoot-tips collected near Milton, N. Y., July 1, 1909. Three or more shoots on each of three bushes of the variety Wilder and five on the variety Fay's Prolific were thus inoculated. In a few cases rubber tissue was used in place of the cotton. One of the shoots wrapped with rubber died, but all others seemed uninjured, though a year later two others had died.

The day after the above inoculations were made, spores from the same collection suspended in sterilized water were placed into some leaf-axiles of seven bushes of the above varieties and surrounded with moist absorbent cotton and covered with grafting wax. Although no infections were noticed during the remainder of the summer, a few of the inoculated shoots failed to leaf out the following spring and were found to have the typical *Dothiorella stromata* and spores of the chromogenic fungus, May 2, 1910.

Macrophoma spores, from material collected near Milton, August 3, 1909, suspended in sterilized water were used to inoculate from six to twelve young shoots on each of twelve bushes on August 11. They were of the varieties Wilder, Fay and Cherry. On four bushes the suspension was applied to scars left by removing leaves, on four others to bark pricked with a large needle, and on four to leaf-axiles. All spore-transfers were covered with grafting wax. No infection became evident until the following spring, when it was found that five of the shoots inoculated on pricked bark had failed to leaf-out, and on May 2, these contained *Dothiorella stromata*, some of which were sporulating. Transfers from the pith tissues proved chromogenic.

Ten days after the above experiment was started it was duplicated, except that mycelial-transfers from +4B₁ and +2C₁ were used for infection material for half the bushes and that potters' clay instead of grafting wax was used for covering. About three weeks later the clay covers were found much cracked and weathered, many having entirely fallen off. No infections resulted.

On April 8, 1910, a suspension was prepared with viable *Macrophoma* spores obtained from dead shoots collected near Milton, N. Y. August 3, 1909, in sterilized water. Transfers were made

to leaf-axiles of many young shoots (greenhouse) which had living, primary cortex. No infection was evident a month later.

The above experiment was repeated April 21, using spores from the same source. Some shoots had living and others dead primary cortex. No infection was noticeable a month and a half afterwards, but bits of bark taken from a number of inoculated leaf-axile regions after the removal of the primary cortex, when transferred to alkaline starch-paste, developed fungous growths which resulted in the production of the characteristic purplish-pink color.

The experiment was again repeated on April 30 except that the suspension was transferred to and sealed in grafting-wax cups made about leaf-petioles of shoots, some of which had living and others dead primary cortex. Six weeks later no evidence of infection was apparent, but the bark under the primary cortex of three out of six shoots tested developed the chromogen on starch paste.

On the same date the experiment was duplicated, using a suspension of *Dothiorella* spores which had exuded from large botryose stromata near the base of a dead bush (greenhouse) that had been inoculated with +A₄. No visible infection occurred.

On June 6, 1910, some bits of bark thickly set with *Macrophoma* pycnidia and others with sporulating *Dothiorella* stromata were firmly pressed against the bark of young shoots with bands of grafting wax. The *Macrophoma* material was obtained from the collection made near Milton on August 3, 1909, and the *Dothiorella* from shoots collected May 5, 1910, and which had died following an inoculation with *Macrophoma* spores, August 11, 1909. A month afterwards there was no infection apparent, but all of the pieces of bark from under the primary cortex of several inoculation points gave rise to the purplish-pink color when transferred to alkaline starch-paste.

MYCELIAL INOCULATIONS.

On March 25, 1901, two one-year-old and two two-year-old shoots of currant bushes in a greenhouse at Ithaca were wound-inoculated by transferring mycelium from subcultures whose orig-

inals had been isolated from newly collected material November, 1900 (—1900 N), to wounds in their bark (made with a sterile instrument) and covered with grafting wax. Check wounds were similarly covered. Three months later none of the inoculated shoots were dead, although some showed slightly discolored tissues about the points of inoculation; the checks seemed normal.

One and two-year-old bushes of the varieties Fay Prolific and Lee's Prolific were used for a similar but more extensive inoculation experiment, in a greenhouse on May 20, 1901; subcultures of —1900 N were employed. Two shoots of each of six plants were wound-inoculated with mycelium from old cultures, and the wounds covered with grafting wax. Six others were similarly treated, but their wounds were covered with cotton. Twelve other plants were treated like the above twelve except that stromatic masses from cultures instead of mycelium was used. Checks were prepared for each set. The results were the same as those following the first experiment.

At Ithaca, N. Y., on July 5, 1901, four wound-inoculations were made in shoots of Lee's Prolific (in the open) with mycelium (+1901M) recently isolated from a dying currant stem. Eleven days afterwards all of the inoculated shoots had wilted, while as many controls were healthy.

A more extensive inoculation experiment was made at the same place July 28, 1901, with mycelium ($\pm$ 1901J) obtained from pycnospores in stromata of old currant stems. Ten green shoots of Lee Prolific in a greenhouse were wound-inoculated; five wounds were covered with grafting wax and five with cotton. Ten shoots, out in the open and already having browned primary cortex on the current season's growth, were similarly inoculated and covered. Ten shoots of *R. Grossularia* were also similarly inoculated and covered. Series of check wounds for each set were similarly covered with wax and cotton. Ten days later all of the inoculated currant shoots in the greenhouse and all but one of *R. Grossularia* seemed normal, while all except one of the currant shoots in the open had wilted. The checks appeared normal.

In Washington, D. C., on August 16, 1901, subcultures of the above mycelium ($\pm 1901J$) were used to inoculate currant shoots whose primary cortex of the season's growth had already browned. Five wound-inoculations on young shoots were covered with grafting wax, five with cotton and five others with paper. Five wound-inoculations on two-year-old shoots were wax-covered. Five young shoots were inoculated by transferring mycelium to the uninjured tissues and covering them with cotton. Checks were prepared for each set. A little more than a month later one of the young shoots (wax-covered) had died, three of them showed some discolored tissues about their wounds, while one seemed normal. Two of those having the inoculations covered with cotton had died, one seemed normal, and the others had some discolored tissues about their wounds. Four of those covered with paper had died and the other one showed some browned tissues about the wound. One of the two-year-old shoots had died, one seemed normal, and there was more or less browned tissue about the wounds of the others. All of the checks seemed normal.

On June 27, 1907, three shoots of each of twenty-eight two-year-old bushes near Milton, N. Y., were inoculated with transfers from three-day-old cultures of $\pm A_2$, $+A_4$, $-A_5$, $-A_7$, and $+A_8$, which were each transferred to scalpel wounds on three bushes, to bruise-wounds on three, and to uninjured bark of three others. One shoot on each bush was prepared as a check and all were covered with grafting wax. After three weeks all branches inoculated with $\pm A_2$, $+A_4$ and $+A_8$ into scalpel wounds and about half of those in which the transfer was put on bruised bark, had wilted or died down to a little below their inoculations, while only about 2 per ct. of the shoots wound-inoculated with $-A_5$ and $-A_7$ had slight discolorations under the grafting wax. However several of these shoots failed to leaf-out the following spring while by that time some of those inoculated with $\pm A_2$, $+A_4$ and $+A_8$ had died nearly to the ground; both were found to have botryose stromata breaking through the bark, containing a typical mixture of sporulating *Dothiorella*

pycnidia and immature perithecia. The wounds seemed to have developed normal callus in those cases where the plant still lived. The checks remained uninfected.

August 16, 1907, three young shoots in the above plantation were wound-inoculated from fresh cultures of $-A_5$, five from $-A_7$, and fifteen from $\pm A_2$, including seven to uninjured bark. All inoculations and the wounds on five checks were covered with grafting wax. A month later every shoot wound-inoculated with $\pm A_2$ had died to a little below the wax cover; but the uninjured shoots seemed still to have normal bark under the wax. The checks as well as those inoculated with $-A_5$ and $-A_7$ had normal callus about their wounds.

Three shoots of each of six two-year-old bushes which were leafing out in the greenhouse in Geneva were given wound-inoculations from vigorous alfalfa-agar cultures of $\pm A_2$, $+A_4$, $+A_5$, $+2A_2$, $-3A_4$, and $+A_8$, on January 31, 1908. The inoculations and the wounds on two checks were covered with grafting wax. On April 4, $+A_4$, $+A_8$ and $-3A_4$ seemed not to have taken, while $+2A_2$ and $+A_5$ killed in every case, and $\pm A_2$ killed two out of a possible three. The checks were normal. June 15 numerous coils of *Dothiorella* spores were found exuding from large, botryose stromata in the bark of the short main stems of the bushes whose shoots, inoculated with $+A_5$ and $+2A_2$, had died to the ground. Small sporulating stromata were also plentiful on the inoculated branches, but these were not exuding spores, probably because they were drier than those nearer the ground. The spores developed the chromogenic mycelia on alkaline starch-paste. The same stromata, on the same stems and on the basal part of the lower branches, were found to contain large quantities of ascospores, on April 12, 1909, which also were chromogenic. It seems therefore that *Dothiorella* spores may be developed in five months or less, and that the ascospores are mature about a year after infection.

Three very young shoots in the greenhouse were inoculated with $\pm A_2$, February 17, 1908, by transferring the vigorously growing

fungus from a potato-agar tube to the green, tender, primary cortex, covering with sterile moist cotton, and encasing with grafting wax. $+A_3$ and $+A_4$ were similarly used for one plant each. Two of the inoculated shoots from each bush were removed to killing fluid (leaving but one on each plant) at intervals of four days, in order to get some idea of the resulting reaction. On April 4 the remaining shoots inoculated with $\pm A_2$ and $+A_3$ seemed normal except for a slight, blackened cortical hypertrophy at the point of inoculation under the wax, but the shoot inoculated with $+A_4$ was dead to about 2 cm. below the wax cover.

On April 28, 1908, three young shoots on a bush in the greenhouse were wound-inoculated with transfers from a two-day-old culture of $\pm A_2$ on neutral potato-agar, three others similarly treated with $\pm A_2$ from a two-day-old culture on potato-agar made 35 degrees acid on Fuller's scale. From each of both the neutral and acid cultures of $\pm A_2$ transfers were made to uninjured bark of three shoots. All inoculations were covered with grafting wax. The experiment was repeated with both $+A_3$ and $-B$, while $+A_4$ was only transferred to six uninjured shoots from an acid culture. A month later the six shoots wound-inoculated with $\pm A_2$ had died, but the other three seemed normal. The wound inoculations with $+A_3$ also seemed equally effective from both neutral and acid cultures; two of each having died. The twelve shoots inoculated with $-B$ and the six inoculated with $+A_4$ were unaffected. A year afterwards one bush wound-inoculated with $\pm A_2$ and one wound-inoculated with $+A_3$ had died to the ground. The other shoots which had previously been affected had died down to the main axis, and those previously unaffected were still normal. The stromata and spores on the dead bushes were identical with those following the inoculations made January 31, 1908.

In a much blighted plantation near Milton thirteen normal shoots about 5 cm. long were inoculated (May 6, 1908) by placing transfers from vigorous cultures of $+2A_2$ in tubes of potato-agar, to which had been added a decoction from stems with numerous stromata of the blight fungus to uninjured twigs, covering the

transfers with sterile moist absorbent cotton and encasing in grafting wax. An equal number were similarly inoculated with each of $+A_3$ and $-B$ from cultures on the same medium neutralized with calcium hydroxide. A month afterwards all inoculated shoots seemed normal, but a number of leaves with petioles inclosed by cotton-wax covers had died and contained sporulating pycnidia of a *Macrophoma*, which proved nonchromogenic. However three and a half months after inoculation three shoots treated with $+A_3$, three with $+2A_2$ and five with $-B$ were dead; but the presence of a nonchromogenic *Macrophoma* on some of their petioles, and since the bushes were in a diseased patch, as well as because they were dug in autumn, make it uncertain whether death was due to inoculations, natural infections, or some other cause.

Six wound-inoculations were made (June 17, 1908) with each of $-A_2$, $+A_3$, $+2A_2$, $+A_4$, $-3A_1$, $-3A_5$, $-B$, $+2B_1$ and $-2B_3$, from four-day-old potato-agar cultures on young shoots in the Geneva patch, and covered with grafting wax. Three weeks afterwards one shoot of each set inoculated with $-3A_1$, $-3A_5$, and $-B$ had died. Five treated with $+A_3$ and six or all of those inoculated with $+2B_1$ and $+A_4$, but only two with $+2A_2$, and none of those treated with $-2B_3$. Two months after starting the experiment all treated with $+A_3$ had died, four of $+2A_2$, two each of $-A_2$, $-3A_5$ and $-B$, and one each of $-3A_1$ and $-2B_3$. One of the shoots inoculated with $+A_4$ had the typical sporulating pycnidia of *Macrophoma* from which the chromogenic series $+3C$ was obtained. About a year after inoculation several had died either entirely or nearly to the ground, and bore the large botryose stromata on the larger stems and smaller ones on the branches. The large stromata nearer the ground contained numerous immature perithecia and sporulating pycnidia, as well as some viable ascospores. In the stromata on the smaller branches there were sporulating pycnidia and fewer immature perithecia; in fact, the condition was very similar to that following the greenhouse inoculations. Many of the bushes on which the inoculation had taken were

still vegetating normally except that the inoculated shoots had died down a decimeter or two farther.

On June 23, 1908, two young shoots of a bush in the Geneva patch were wound-inoculated with $-A_2^*$ from a fresh culture and covered with grafting wax. The experiment was duplicated with each of $+A_{2d}^{**}$, $-3A_1$, $-B$, $+2B_1$, $-2B_2$ and $+3C_2$ on as many other bushes. A month later the two plants treated with $-3A_1$ and $-B$ seemed entirely normal, the two inoculated with $-A_2$ and $-2B_2$ had each one dead shoot while those on which $+A_{2d}$, $+2B_1$, and $+3C_2$ had been used had each two dead. No additional infections were noticed when examined two months afterwards. However, a year after inoculation a number of the plants on which the fungus had taken had since died to the ground, while in some the inoculated branches were dead, and the uninoculated branches were growing normally. On the dead stems and larger branches were *Botryosphaeria stromata*, some of which contained sporulating pycnidia and immature perithecia; some only one or the other of these spore forms, while a few contained ascospores. It seemed specially important to find that the only plant effectively inoculated with $-2B_2$ was dead, and contained the typical *Botryosphaeria* spores, both in pycnidia and perithecia. Transfers from the pith of this plant, like the mycelium used, proved nonchromogenic on alkaline starch-paste.

July 3, 1908, three-day-old potato-agar cultures of $-A_2$, $-B$, $+B_2$, $-3A_1$, $-2B_2$ and $+3C_2$ were each used to make two wound-inoculations on shoots of separate plants, the wounds being covered with grafting wax. After twenty days only one of the two shoots inoculated with $-3A_1$ had died, but all other inoculations had taken. A month later no further change was observed.

On the above date similar cultures of $+A_{2d}$, $+2B_1$, and $+3C_2$ were used to make six wound-inoculations on *R. nigrum* bushes in the Geneva patch, and covered with grafting wax. On the fifth of the following August the inoculated shoots seemed to have been

* A subculture of $\pm A_2$ after chromogenesis had been lost.

** A subculture of one of the remaining original cultures of $\pm A_2$ which had been kept in stock since June, 1907, without being retransferred.

dead some weeks; they had died down from 1—4 dm. below the wax cover while *R. vulgare* shoots usually die but 1—4 cm. below. About a year later most of the aerial parts of the inoculated bushes had died and the dead stems and larger branches contained the typically mixed stromata in abundance. (See Plate VII.)

Vigorously growing cultures of $+3B_1$, $+3B_2$, $+3B_3$, $+4B_1$, $+4B_2$, $+4B_3$ and $+4B_4$ were each used to wound-inoculate three shoots in the Geneva patch (August 10, 1908) and similar cultures of $-5B_1$ and $-6B_3$ were each wound-inoculated on six others. Ten days later two of each set of three inoculated with $+3B_1$, $+3B_2$, $+3B_3$, $+4B_1$, $+4B_2$, $+4B_3$ and $+4B_4$ had died, all three inoculated with $+4B_3$, and none of either set of six treated with $-5B_1$ and $-6B_3$ seemed affected.

On June 28, 1909, transfers from young cultures of $-B$, $-5B_1$, $-5B_2$, $-6B_3$, $-6B_4$, $-10B$, $+C_1$, $+C_2$, $+C_3$, $+4C_3$, $+4C_5$, $+4C_7$, $+7C_1$, $+7C_2$ and $+7C_3$ were each wound-inoculated into two shoots in the Geneva patch, and covered with grafting wax. At the end of a month all those inoculated with $+C_1$, $+C_2$, $+C_3$, $+4C_3$, $+4C_5$, $+4C_7$, $+7C_1$, $+7C_2$ and $+7C_3$ were dead, one of each of those treated with $-B$, $-6B_3$ and $-6B_4$ had died; while those inoculated with $-5B_1$, $-5B_2$ and $-10B$ were normal. Pith transfers from dead shoots inoculated with $-5B_2$ and $-6B_3$ proved nonchromogenic on alkaline starch-paste.

The day after the above date a similar experiment was started by using $+2C_1$, $+2C_2$, $+2C_3$, $+3C_1$, $+3C_2$, $-5C_2$, $-5C_3$, $+6C_1$, $+6C_2$ and $+6C_4$, except that four inoculations were made from each culture. About a month later all shoots inoculated except those treated with $-5C_2$ and two treated with $-5C_3$ were dead. Pith transfers from the dead shoots inoculated with $-5C_3$ proved non-chromogenic on alkaline starch-paste.

Growing potato-agar cultures of $-B$, $-5B_1$, $-5B_2$, $-6B_3$ and $-6B_4$ were each wound-inoculated on two shoots in the Geneva patch, July 8, 1909. The transfers and the wounds on four checks were covered with grafting wax. Twenty-two days after the inoculations were made the shoots treated with $-5B_2$, $-6B_3$,

and the checks were normal, while two of the four treated with $-5B_1$ and five of each six inoculated with $-B$ and $-6B_s$ had died. Pith transfers from the dead shoots inoculated with $-B$, $-5B_1$, and $-6B_s$ were nonchromogenic on alkaline starch-paste.

On August 13, 1909, an experiment was started to induce the production of *Macrophoma* pycnidia on inoculated shoots by inserting eight shoots wound-inoculated with the chromogens $+10B$ and $+12C_1$ into one-liter Erlenmyer flasks and plugging the openings with cotton. The flasks were supported by tying them to stakes. At the end of a month the inoculated shoots had all died, but no indication of pycnidia was observed.

Transfers from vigorous cultures of $+7B_s$ and $+8C_1$ were placed on dying primary cortex of numerous shoots just basal to their leaf-petioles, June 13, 1910, and covered with grafting wax. Ten days later only a slight discoloration of the primary cortex and in a few cases some of the outer cell-layers of the bark were blackened.

On June 30, 1910, the experiment was repeated using new cultures of $+7B_s$ and $+7C_s$. The result was the same as in the previous experiment. But on February 24, 1911, about a third of the inoculated shoots of both experiments had either one or more of the included leaf traces blackened practically to the pith, and often with a blackened xylem group running lengthwise the entered wood cylinder, or much of the pith and wood blackened both above and below. Typically blackened pieces of wood cut from the interior of six such shoots were found, by test, to contain the chromogenic fungus.

On July 13, 1910, transfers from cultures of a chromogen, isolated from the pith of shoots which had been naturally infected near Milton a few weeks previously, were placed on the tips of many shoots in the Geneva patch and the points of inoculation covered with grafting wax. No infection seemed to follow, but during the following winter nearly half of the inoculated shoot-tips had been killed back from 0.5—3 cm., and were found to contain the chromogenic fungus.

THE SEASONAL HISTORY OF THE HOST AS RELATED TO NATURAL AND ARTIFICIAL INFECTION.

Although the inoculation experiments are not uniformly positive they are practically so when only wound-inoculations of the chromogenic fungus are considered, but taken as a whole, the results are erratic. The attempts to inoculate uninjured *Ribes* plants both with spores and with mycelia were mostly negative, although at certain times and when the transfers were sufficiently protected, a fair percentage of successful infections resulted. It seemed very significant that the time of year or the growth-stage of currants during which some infections through uninjured tissues were secured, and during which wound-inoculations were most successful, corresponds to the period or stage of development of the host in which infections occur naturally. The cultivated varieties of currants usually cease their elongation growth before mid-summer, and the following vegetative activities consist mainly of peripheral growth of shoots and in differentiation processes, such as the ripening of the fruit, the development of phellogen and periderm in the outer layers of the cortex, cutting off the outgrown and dying primary cortex; the differentiation or ripening of the stele tissues, as well as the development of resting buds, and the elaboration and storage of reserve foods for the following spring, or the next period of cambial activity. According to a series of titration tests of expressed sap from shoots during the various vegetative periods, the acidity becomes somewhat lower during the early part of this maturation period, while that of the leaves increases above that of some earlier stages. As may be gathered from the field observations made, most of the natural infections occurred during the earlier part of this differentiation period. Even when shoots which undergo a short and erratic secondary period of elongation became infected, the parasite was usually found to have entered the region of discolored primary cortex just basal to the green tip resulting from the secondary period of elongation.

In short it seems that currants are most susceptible to this parasite during the period of transition from active elongation-growth to that of the maturation stages; in the stage of transition from longitudinal to transverse growth-tension. It is perhaps impossible to say whether susceptibility in this case depends upon the physical state of the host and the chemical condition of its sap or upon the dying of the primary cortex, as affording an easy transition from the dead to the living tissues, before the cork-layer has become sufficiently resistant; or upon both. The simple experiments by Holzinger¹⁹ upon which he bases an hypothesis of natural immunity seem interesting in this connection. Some semi-permeable copper-ferrocyanide clay-cups and some glass cylinders were filled with a "beer-sugar solution" and kept surrounded by water, or some solution at 37° C., and at room temperature. In from one to several days the solutions had become turbid and numerous fungus and bacterial growths were present in the glass cylinders, while in the clay cells very little turbidity occurred. On decreasing the cell-lumen of the clay cells by inserting a glass cylinder, the solution was frequently still clear and entirely free from fungus and bacterial growths at the end of ten days. From such experiments it is concluded that "osmotic motion" hinders or prevents germ development but does not prevent turbidity due to chemical or enzymotic activities. It is therefore thought probable that normal living tissues are immune on account of osmotic activities in their cells, and that a reduction or cessation of these activities permits infection. However, since the relative degrees of "osmotic activity" in the various seasonal stages of currants have not been determined, no definite comparison can be made between the period of greatest susceptibility and the relative osmotic condition of the sap during that time. But even if this time or stage of least "osmotic activity" coincided with the period of greatest sus-

19. F. Holzinger.

- I. Eine Theorie der natürlichen Immunität des Gewebes. Experimentelle Studie. *Biochem. Centbl.* 7:465-6. 1908.
- II. Über den Einfluss osmotischer Vorgänge im Medium auf das Wachstum von Mikroorganismen. *Centbl. Bakt.* II 21:449-59. 1908.
- III. Über sterilisatorische Eigenschaften osmotischer Strömungen. *Biochem. Centbl.* 8:381. 1909.

ceptibility the question would of course still be unsettled because other equally important factors may be involved.

As may be seen from Plate IV the dying of the primary cortex reduces greatly the living connection between leaf and axis, and therefore during the time when the period of greatest cambial activity and active elongation merges into the maturation or ripening stage a fungus may perhaps enter more readily at leaf-petioles than earlier, and possibly more readily than at any other point. The actual presence of the chromogenic fungus in leaf-petioles even before there has been an invasion of the axis indicates that it often enters petioles and then the axis through the traces of the former; for, in cases of petiole-infection, the latter were often found discolored, while the surrounding tissues of the axis were yet normal. In view of the above inoculation experiments and field observations, this appears a possible explanation of the occurrence of at least a part of the infections, although the conditions of the sap and the kind and degree of growth-tensions existing in the shoots of the host may be of some importance.

CHROMOGENESIS AS A DIAGNOSTIC CHARACTERISTIC.

The striking anomalies of the earlier inoculation experiments were enigmatic and inexplicable in the extreme, and no explanation was afforded until much later. Similar sets of inoculations gave widely differing results, and sometimes results of certain parts of a set would differ from others although the mycelium used in the experiment might have been isolated from the same type of material and might appear the same throughout.

In May, 1901, some wound-inoculations with cultures obtained from the black stromata of material collected near Marlboro, N. Y., during the preceding November proved negative; and a repetition of the experiment about two months later, using subcultures of the same mycelium, gave the same results. However, similar inoculations with mycelium isolated from freshly collected, dying plants proved effective in all the inoculations made,

and that within nine days. This *seemed* to indicate that mycelium from the older stages of the fungus is but slightly, if at all, parasitic while that from dying plants is decidedly pathogenic; but this did not prove to be the correct explanation.

In July of the same year mycelia obtained from pycnosporos of recently collected material were used to inoculate five shoots of each of four *R. vulgare* bushes and two bushes of *R. Grossularia*. All inoculated shoots on *R. vulgare* plants and one on *R. Grossularia* were dead in ten days. The experiment was duplicated about a month later with subcultures from the same source. The percentage of dead shoots resulting was about the same as in the former trial, but the dead and living inoculated shoots were more irregularly distributed among the species of the hosts used.

During the latter part of June, 1907, a very large series of inoculations was made with mycelia obtained from the pith of currant stems collected earlier in the month near Milton, N. Y. Mycelia $\pm A_2$, $+A_3$, and $+A_4$, from the dead parts of as many shoots of the previous season's growth and bearing many small *Dothiorella stromata* some of which were sporulating; and mycelia $-A_5$, $-A_6$, $-A_7$ and $+A_8$, from older stems (which had also died during the preceding season and bore large stromata containing immature perithecia and some sporulating pycnidia) were each used to inoculate the shoots of several different bushes.

After three weeks all shoots wound-inoculated with $\pm A_2$, $+A_3$, $+A_4$ and $+A_8$ were dead, while all others appeared normal although slight browning of tissues had occurred in some cases.

During the following August a similar experiment was made, using mycelia $\pm A_2$, $-A_5$, and $-A_7$, and was followed by the same results. This seemed again to indicate that mycelia from the younger stages of the fungus are strongly pathogenic; with, however, the striking exception of $+A_8$ which was obtained from the pith of a stem bearing large stromata with numerous immature perithecia. These enigmatic differences obtained in inoculation experiments with mycelia, apparently of the same fungus, were somewhat cleared up during the following winter

when it was found that all decidedly parasitic mycelia of series $\pm A$ ($\pm A_2$, $+A_3$, $+A_4$, and $+A_5$) develop a strong purplish-pink color on neutral or alkaline starch-paste while the others failed to produce the color. In the light of all the results, it now seems probable that the different results were due to an actual physiological difference in the inoculating material employed.

The relation between chromogenesis and pathogenicity seemed to afford an important means of determining the efficiency of mycelia isolated from blighted plants. Those of series $+2A$ which had been isolated from the pith of dead shoot-tips (August, 1907) but not used for inoculations at the time, were found also to be chromogenic, and later experiments proved them parasitic. On the other hand, the whole of series $-3A$, from the pith of stromatic stems, and series $-B$, $-5B$, and $-6B$, from the ascospores on stems like those from which numbers 5-8 of series $\pm A$ were obtained, proved nonchromogenic and also nonparasitic except at certain times as may be seen by comparing the results of inoculation experiments, especially those made on May 6, June 23, and July 3, 1908, June 28 and July 8, 1909, with those made June 27 and August 16, 1907, and August 10, 1908. Perhaps differences in the condition of the host caused some of these irregular results. From these inoculation experiments it may also be seen that in *exceptional* cases a culture of a chromogen failed to take. However, series $+C$ and $+4C$, which were made from ascospores developed on bushes that had died in a greenhouse as a result of inoculating them with $\pm A_2$ and other chromogens, proved both chromogenic and parasitic. It therefore seemed probable that ascospores developed from chromogenic mycelia also produce only chromogenic mycelia. All of series $\pm 2B$, which was secured (May, 1908) from the pith of large, partially green stems bearing stromata like those giving rise to the latter part of series $\pm A$, except $-2B_3$, gave the characteristic color on starch paste. The results of inoculation tests with the members of the series coincided with their color reactions.

Sometime between May 18 and June 2, 1908, $\pm A_2$ lost its

chromogenesis and also its pathogenicity, making it appear possible that chromogenesis and pathogenicity may be lost and perhaps regained in this fungus somewhat as chromogenesis is said to be lost and regained in certain bacteria. However, all attempts, during three years, to induce —A₂, —2B₂, and the members of nonchromogenic series to develop color were futile. They grew luxuriantly as usual on various media, and neither changes of temperature, of the medium, or its reaction gave unusual results. They were grown at the minimum, optimum, and maximum temperatures, and some subcultures, which had overgrown all the available surface in flasks of potato-agar and on pieces of currant stems, were wintered out of doors and others were kept in a thermostat at 37°. Neither transfers from those wintering outside nor from those kept at a high temperature proved chromogenic. It also seemed possible that passing a nonchromogen through the host might induce chromogenesis, but re-isolations made from a number of the bushes which had died after they were inoculated with the nonchromogenic form, always developed nonchromogenic mycelia. Nor was it found possible to cause chromogenic mycelia to lose that power by subjecting them to unfavorable growth conditions; color was always produced when they were regrown on alkaline starch-paste. It therefore seems that chromogenesis is a fixed characteristic, and that we have two physiologically distinct organisms that are very similar morphologically.

A REVIEW OF SOME LITERATURE ON CHROMOGENESIS.

The development of nonchromogenic or colorless strains seems to occur quite commonly in growing *Bacillus prodigiosus*, especially from degenerate or old cultures. Miss Hefferan²⁰ made five second-dilution, poured-plate cultures of this organism obtained from different sources; one was said to have been a colorless strain during at least two months preceding her acquisition

20. M. Hefferan. A comparative and experimental study of bacilli producing red pigment. *Centbl. Bakt.* II 11:311-17, 456-75, 520-40. 1904.

of it. In the first test, a plate made from the white strain developed 48 white and 2 chromogenic colonies, while a plate from one of the chromogenic strains produced 35 white and 3 chromogenic colonies. The other three strains developed only pigmented colonies though one of them gave a very low count (5). In a second test, fifteen days later, a plate from the nonpigmented strain produced 50 red and 5 white colonies, while a plate from the pigmented strain which gave the low count in the first test, produced 26 colored and 1 colorless colonies. All transfers made from red and some from white colonies gave only red colonies, but some white ones are said to have proved apparently constant. The reduction of the relative numbers of white "sports" in such experiments are taken to indicate that "the colorless variations of the original cultures had gained an ascendancy over the red type through continued unfavorable conditions." However, the rejuvenating process or the frequent retransference to congenial media, does not always result in reducing the number of so-called discontinuous variations. "It sometimes occurs that an old culture on neutral agar which has stood in the stock case two or three months will give a brilliant pigment on the first transference to neutral agar again, while successive inoculations will seem to diminish the pigment production."

Bacteriologists generally consider chromogenesis an easily disturbed physiological characteristic, and in view of the variety of results recorded in the literature, it seems a justifiable conclusion. In fact, it is claimed by some that by growing *Bacillus prodigiosus* at 37-39° C., or on alkaline media through many generations, nonchromogenic forms result, some of which fail to regain chromogenesis when again grown on acid media at lower temperatures. Since the development of a pigment is perhaps an end-reaction between certain metabolic by-products and the surrounding medium, one should expect a more constant result when the chemical reaction and make-up of the medium, as well as the general environment, are fairly constant. The uselessness to an organism of end-reactions resulting in the accumulation of colored com-

pounds cannot be taken to indicate that the metabolic changes giving rise to the eliminated by-products which may form the bases for such pigments are not essential to normal vegetation, any more than the catabolic changes preceding the development of such useless end-products as alcohol, CO_2 , or ptomaines can be considered as nonessential. But when the substratum and environment are such as to react with certain end-products in a certain way it seems unnecessary to assume that the more essential metabolic changes preceding the end-reaction have been changed or affected thereby. Since the end-reactions of such professedly essential functions can be diverted in some organisms it may be that chromogenesis in a bacterial species is not as variable as the data cited by some authors seems to indicate. Sullivan concludes that "a variety of *B. pyocyaneus* producing both pyocyanin and the fluorescent pigment can be made to produce pyocyanin alone, pyocyanin and a fluorescent pigment, or the fluorescent pigment alone, according to the medium upon which it is grown; the purely fluorescent bacteria, including the fluorescent variety of *B. pyocyaneus*, cannot be made to take up the pyocyanin function; a variety of *B. pyocyaneus* producing pyocyanin only cannot be made to take up the fluorescent function."²¹

At any rate, the literature of chromogenesis among the fungi proper does not seem to support the idea that it is an unreliable characteristic when the environment does not vary beyond certain limits or critical points, as may be seen from some typical cases recorded in mycological literature.

According to Constantin *Eurotiopsis Gayoni*²² develops a strong red color on starch paste or grape juice but grows poorly and without chromogenesis on potato. Later Laborde²³ concluded that it generates its typical red color on media with only a slightly acid,

21. l. c. p. 134.

22. J. Constantin. *Eurotiopsis*, nouveau genre d'Ascomycetes. *Bul. de la Soc. Bot. France*, 15:236. 1893.

23. J. Laborde. Recherches physiologique sur une moisissure nouvelle, l'*Eurotiopsis Gayoni*. Thèse présentée à la Faculté des Sciences de Paris. 1896.

neutral, or alkaline reaction containing carbohydrate, or a protein like casein, but that no color is produced in strongly acid media.

Milburn²⁴ found that *Hypocrea rufa* grown on certain media, having an acid reaction, developed green colored spores, but when the media were made alkaline yellow spores were produced. Since some adverse environmental factors inhibit sporulation the influence on chromogenesis was not determined. However, it was shown that colorless spores may be obtained by using media with a high osmotic pressure, and that changes in temperature seemed to have no relation to the color of the resulting pigment. He also found that an *Aspergillus niger*, which appeared as a contamination in other cultures, produced its characteristic yellow color on various acid media independently of other environmental factors; and he verified in part Laurent in showing that *Bacillus ruber balticus* develops an orange-red pigment on alkaline, a reddish-violet on acid, and a brick-red on neutral media. The color of the pigment developed was found to depend more fundamentally upon temperature than on the initial reaction of media, because, as also Laurent formerly observed, *Bacillus ruber balticus* induces the formation of acid in media at temperatures above 20°C. in which alkalis are developed at lower temperatures.

Doebelt²⁵ observed that *Penicillium africanum* produces a typical red color when grown on either liquid or solid media containing sugars or starches as a source of carbon, and that the color becomes stronger or darker red when asparagin or peptone is used with it. But on neutralized or alkaline media no color was produced until an acid reaction had been developed by the growing fungus. The color was produced both in the dark and in strong light, but the optimum temperature for growth was found to be above that for chromogenesis.

From extensive cultural work on his *Neocosmospora vasinfecta* Smith²⁶ concludes that on neutral or acid media containing starch

24. T. Milburn. Ueber Aenderungen der Farben bei Pilzen und Bakterien. *Centbl. Bakt.* II 13:129-38, 257-76. 1904.

25. H. Doebelt. Beiträge zur kenntnis eines pigmentbildenden *Penicilliums*. *Ann. Mycol.* 7:315-38. 1909.

26. E. F. Smith. Wilt disease of cotton, watermelon and cowpea. U. S. Dept. Agl., Div. Veg. Physiol. and Path. Bul. 17:1-53. 1899.

various shades of red and violet colors are produced, and that alkali inhibits their formation. In using what may have been the same fungus, Bessey²⁷ extended these findings by showing that various sugars, some of the higher alcohols, as well as a number of organic acids, when used as the sources of carbon with Knop's solution, resulted in the production of the red color; i. e., these various carbon sources supplied in an acid medium led to color formation. The light and temperature relations seemed to have been the same for growth and chromogenesis. The thought is expressed by Bessey that further investigations into the chromogenesis of the fungi would doubtless lead to the separation of these organisms into groups as distinguished by their reactions to environmental factors. Thom's work²⁸ on the genus *Penicillium* affords a good illustration of the successful application of physiological characteristics in the determination and description of species. He found that the chromogenic species which were thoroughly tested always gave the same definite color reactions under certain culture conditions.

A POSSIBLE RELATION OF THE SPECIES AND ITS FORM.

This array of facts regarding the definiteness of color reactions among fungi does not explain the change which apparently occurred in a sub-culture of A_2 nor how the whole or parts of culture series, isolated from blighted *Ribes* plants produce the color and others do not; but it rather makes one wonder whether it is really necessary to assume that we have here an example of a fungus which mysteriously changes from a chromogen to a nonchromogen in culture. At least a plausible explanation of this riddle is suggested by the following experiment.

On December 8, 1910, the chromogens $+7B_5$, $+C_4$ and $+7C_1$, and the nonchromogens $-B$, $-5B_1$, and $-6B_3$ were transferred to flasks of alkaline starch-paste, placing a transfer of a chromo-

27. E. A. Bessey. Über die Bedingungen der Farbenbildung bei *Fusarium*. *Flora. etc.* 93:301-34. 1904.

28. C. Thom. Cultural studies of species of *Penicillium*. U. S. Dept. Agr. Bur. Am. Ind. Bul. 118:1-107. 1910.

gen and one of a nonchromogen into each flask grouped as indicated in row 1 of the diagram below. Six days afterwards the mycelia of the two transfers in each flask had met and intermingled more or less, as indicated by the dotted lines. A transfer was then made to a tube of potato-agar from the region of each flask where the mycelia intermingled. On December 16, after the slants had been practically uniformly covered by fungous growth, G. T. French of the Botanical Department in this Station kindly made transfers from them to fresh tubes. Late the following day three transfers were made from each of the fresh tubes to

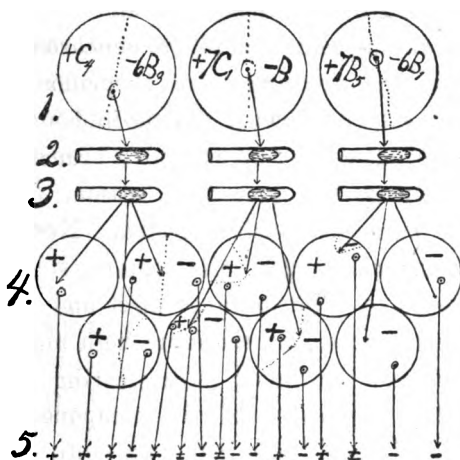


FIG. 1.—DIAGRAMMATIC REPRESENTATION OF AN EXPERIMENT TO ILLUSTRATE POSSIBLE ASSOCIATION AND SEPARATION OF BOTRYOSPHERIA RIBIS AND ITS FORM.

1. Flasks of starch paste to which transfers were made at points indicated by labels. Broken lines show meeting points of mycelia.

2. Potato-agar tubes, with locations of transfers indicated by arrows.

3. Similar tubes to which transfers from tubes in 2 were made by a disinterested person.

4. Starch-paste flasks, with locations of transfers from tubes in 3 indicated by arrows.

5. Reactions of transfers taken from indicated regions in 4 and tested in other flasks of alkaline starch-paste.

as many flasks of alkaline starch-paste. On December 20, the flasks seemed to be of three types as regards the reaction that had occurred in them; some flasks seemed to contain the chromogen pure, others nonchromogens pure, and some a mixture of both types of mycelia, as indicated by the reactions with the substratum. Several transfers were made from the flasks apparently containing but one of the component mycelia, as well as from the different regions of the mixed flasks, to another series of starch-paste flasks. The result was that apparently pure cultures of chromogens were secured from several flasks, as shown in 5 of the diagram.

That this may be a correct explanation of the confusion is in-

dicated by an examination of the data on the origin and record of the different culture series. Although several hundred original cultures were made from both the pith and the *Macrophoma* spores of recently infected young shoots and from infected leaf-petioles, every one of them proved chromogenic on starch paste. Out of the large numbers of isolations made from the pith of such shoots as had been infected during the preceding season (and at the time of making the cultures had died down only 2-5 dm.) only one culture of one series proved nonchromogenic ($-2B_3$). On the other hand some of both spore and tissue transfers from *Ribes* stems which had died to the ground or nearly so, and which bore the large stromata, proved chromogenic and others nonchromogenic. It often happens that large fruiting stems or primary branches of a currant bush wilt rather suddenly during midsummer, due to an invasion by the chromogenic fungus from a branch, whose tip it had infected during the preceding season, or from a small spur which had been previously infected. Now, it seems probable that the nonchromogen also enters such dying stems and that the mycelia of the two fungi meet and to some extent intermingle in their tissues, and therefore both may be present in such tissue transfers. Continued retransferring of such cultures may lead to the separation of the component mycelia. The fact that the one of the old, original stock cultures of $\pm A_2$, which had been stored in June, 1907, with a portion of the currant stem from the pith of which it had been obtained, proved chromogenic upon direct transfer of a portion of the dried remains to starch paste also supports the conclusion indicated in the above experiment. Some additional circumstantial evidence is that about two months after digging, practically every stem of large piles of currant bushes resulting from uprooting the whole of a badly diseased plantation during late summer, bore large stromata of the nonchromogenic fungus which produced abundant spores during the following June and July. All but comparatively few of the numerous tests made from these piles indicated

the presence of the nonchromogenic fungus. Culture series —5B and —6B originated from such ascospores. It appears therefore that we have here two physiologically distinct fungi which probably do not change as regards this distinguishing reaction, although they seem to constitute but one morphological species.

TECHNICAL DESCRIPTION OF BOTRYOSPHERIA RIBIS AND OF ITS FORM.

Generic position.—This is a fungus of the type figured and described by the Tulasne Brothers as *Dothidea melanops*,²⁹ later made the type species of the new genus MELANOPS by Nitschke.³⁰ In 1863 de Cesati and de Notaris³¹ founded the genus BOTRYOSPHERIA in which forms like *D. melanops* were included, likewise some phragmosporic forms. It is claimed, however, that since *Gibberella pulicaris* (Fries) Sacc. may have been taken as the type species of Botryosphæria, Nitschke's *Melanops*³² should be used for forms like the original *Dothidea melanops* Tul. However, Saccardo redefined the limits of the genus Botryosphæria³³ by excluding the forms which develop septate spores. Even though the generic name *Melanopa* may eventually replace Botryosphæria for fungi of this type, because apparently the type species of the latter was subsequently transferred to *Gibberella*, it seems unnecessary to revive an unused name for the isolated case involved in this investigation.

Specific relationships.—It seems possible that the *Dothiorella* form of this fungus has sometimes been confused with *Dothiorella Ribis* (Fuckel) Sacc.,³⁴ because the form and size of the spores

29. L. R. Tulasne and C. Tulasne. *Selecta Fungorum Carpologia*, 2:73-75. 1863.

30. L. Fuckel *Symbolæ Mycologicæ*, 225. 1869.

31. V. de Cesati and G. de Notaris. Schema di classificazione degli Sferiacei italici aschigeri più o meno appartenenti ai generi Sphaeria nell'antico significato attribuitogli da Persoon. *Commentario Soc. Crittogam Ital.* 1:177-240. 1863.

32. C. L. Shear. Life history of *Melanops quercuum* (Schw.) Rehm forma vitis Sacc. *Science N. S.* 31:748. 1910.

33. P. A. Saccardo. *Sylloge Pyrenomycetum omnium hucusque cognitorum*. 1:456. 1882.

34. Fuckel, l. c. p. 205.

are the same and also because the latter has been assigned a wide range of hosts. But, since *Dothiorella Ribis* (Fuckel) Sacc. is said to be a pycnidial form of *Diaporthe Strumella* (Fries) Fuckel they cannot be identical. *Dothiorella ribicola* Ellis and Barth. also has some points in common with the fungus under consideration in this paper, but the differences are more important. The stromata, pycnidia, and spores of the former are smaller, and its spores are guttulate; the minimal measurements of pycnidia and spores of the latter usually exceed the maximal of those of the former; and, besides, the spores of *Dothiorella ribicola* are 2-4 guttulate while the others are nonguttulate.

SPORE FORMS.

Various fungi were sometimes found on dead stems of blighted currant bushes. In fact, during the early part of this investigation cultures were made from the dark-brown spores of a Sphaeropsis-like fungus found on such stems because it appeared to be a possible spore-form of the blight fungus; however, inoculation experiments made in May, 1901, were entirely negative, and observations during the past four years make it evident that that Haplosporella, like many other Ribes fungi, is only at times an accidental associate of the blight fungus. But the only spore-forms always found on blighted bushes and most commonly exclusive of all others, and the only spore-forms produced on bushes killed by inoculation were a *Dothiorella*-form which was usually associated with or followed by an ascigerous-form in the same stromata, and a *Macrophoma*-form which was only developed on shoots invaded or infected while yet somewhat succulent.

The ascogenous form.—The stromata are black and more or less pulvinate. The outer surface is botryose, resulting from extruding perithecia. The stromata are 1-4 mm. in diameter, usually 2-3 mm. and surrounded by the fissured periderm. They are irregularly scattered and rupture the periderm transversely, or arranged in more or less definite, longitudinal rows which sometimes appear as single, much elongated stromata. When occurring near

the ground, on the basal parts of large stems, the irregularly disposed stromata are often in rather thin, confluent groups.

The perithecia are somewhat top-shaped, with papillate ostiola, and they usually project to the extent of about one-third of the height above the surface of the stromata, although sometimes they may be practically superficial or only the ostiola may emerge. The perithecia are few to many (mostly) in a stroma and usually interspersed among pycnidia. Sometimes they occur alone or again with what appear to be old pycnidial cavities in the deeper layers. The perithecia measure $175\text{--}250\ \mu$ in width. The asci are clavate, measure $80\text{--}120 \times 17\text{--}20\ \mu$, and interspersed among them are numerous filiform paraphyses. The spores are fusoid, continuous, hyaline, nonguttulate except sometimes in old weathered material, and measure $16\text{--}23 \times 5\text{--}7\ \mu$.

The stylosporoc forms.—(1) The pycnidia of the compound stylosporoc form are borne in the same stromata, or stromata similar to the ones bearing the perithecia, and they are usually of the same size, although frequently when interspersed with perithecia some may be more than twice that size. The ordinary pycnidia usually protrude more or less and give the stromata a botryose appearance, but the large ones are commonly wholly immersed, and have pore-like ostiola. The spores are fusoid, nonguttulate, continuous, hyaline, and measure $18\text{--}31 \times 4.5\text{--}8\ \mu$. (2) The pycnidia of the simple stylosporoc form are imbedded in the outer bark under the much-raised primary cortex of young shoots. They are depressed globular $175\text{--}250\ \mu$ wide, and usually puncture the primary cortex with papillate ostiola. The spores are fusoid, nonguttulate, hyaline, continuous, and measure $16\text{--}25 \times 4.5\text{--}7.5\ \mu$.

Physiological and cultural characteristics.—The mycelia of all the above spore-forms of *B. Ribis* grow readily on most solid media but only on a few liquid media, produce a strong purplish-pink color on neutral or alkaline starch-paste, when grown in day-

light; and are parasitic on cultivated varieties of *Ribes vulgare*, *R. nigrum* and *R. Grossularia*.

BOTRYOSPHERIA RIBIS FORMA ACHROMOGENA.

Morphological characteristics.—The morphology of the form resembles that of the species except that its stromata are often more pulvinate and that no authentic *Macrophoma*-form has been found connected with it.

Physiological and cultural characteristics.—The cultural characteristics are the same as that of the species as far as studied except that no purplish-pink color is developed on starch paste, and that it is primarily saprophytic; for it takes but rarely when wound-inoculated into *Ribes vulgare*, although the fruiting-bodies are commonly present on dead stems of that species.

NOTE.—All of the spore-forms will be issued next autumn in Century 35 of Bartholomew's *Fungi Columbiani*.

SOME DEDUCTIONS FROM THIS INVESTIGATION BEARING ON THE CONTROL OF BOTRYOSPHERIA BLIGHT.

The general practice among currant-growers is to do their pruning during the winter months, and many of them spray once in May with a combination fungicidal and insecticidal spray. However, since *Botryosphæria* blight is prevalent and destructive in plantations given that treatment it is patent that there is something wrong with the practice.

Observations in blighted plantations in the Hudson Valley, about Rochester, N. Y., as well as in the experimental patch at Geneva show that the causal fungus produces its second type of pycnosporos (Dothiorella type) on blighted stems in late May and June, and that they are most numerous during late June and early July; while the early ascospores usually mature in late June but are most abundant during the middle of July. It was also found that infections occur only during the time these spores are

present in large numbers and that the number of infections taking place seemed to be proportional to the amount of infectious material in or near a plantation; and also that a beetle which eats the sporulating stromata of the fungus and whose larva is a borer in currant stems of blighted plantations, is present during the infection period and may be a factor in the dissemination and inoculation of the fungus. The bark of younger currant stems is covered more or less completely by disintegrating primary cortex, and therefore discolored, dead stretches and areas of bark resulting from late infections are *not evident* after the plants are defoliated.

Now, in view of the observations summarized above, it appears that at least a decided advance may be made in the control of this disease by slightly modifying the present pruning practice. Instead of doing it in winter while much of the infected material is not apparent, the pruning could perhaps more profitably be done during the month of May, when absence of leaves marks many of even the obscure infections. Again, in place of carelessly collecting the prunings and piling them along roads and fences where they are often left throughout the following summer, they should be carefully collected and burned before the end of May, so as to destroy both the fungus and the pupating mycophagous beetle which is present in many of the stromatic stems and usually emerges after the middle of May.

During the summer of 1909 the time and intervals of spraying the four-row plats of a blight-free plantation in the Hudson Valley (which is used by the Station to test the efficiency of Bordeaux mixture for controlling the various fungus diseases of currants) were changed so that they might test the view developed from the observations on the time of occurrence of *Botryosphaeria* infection. Although comparatively few infections occurred in the whole plantation their distribution was evidently not determined by the presence or absence of spray-mixture for the largest number of infections happened to take place in plats sprayed two and three times while two of the check-plats showed no infection.

CONCLUSION.

Usually several fungi are more or less apparent in blighted plantations but as a result of this investigation it has become evident that *Botryosphaeria Ribis* is the cause of the blight and that *Nectria cinnabarina*, a Haplosporella, and several other fungi are only saprophytes, or at least only of secondary importance. Inoculation experiments not only proved the last-mentioned forms saprophytic but also that the former species is made up of a parasitic species proper and of a saprophytic form which resembles it morphologically.

It was found that by growing the two in daylight on alkaline starch-paste *B. Ribis* is differentiated from its form and also from the other saprophytic fungi commonly present in blighted plantations, because it alone develops a bright purplish-pink color.

Chromogenesis seems to have a very high diagnostic value when the initial reaction of a suitable medium is such as the organism requires to develop its color. In that way the organism to be tested need not first develop the required reaction of the medium by vigorous vegetation but it is provided at the outset, so that if the organism vegetates at all the color will appear.

Since *B. Ribis* failed to sporulate in ordinary culture media, yet seemed to produce three spore-forms on the host, various types of culture-vessels and media were employed in an endeavor to find the relations of the spore-forms one to the other, but without success. Portions of the host bearing the simpler spore-forms were subjected to many differing environments in the hope of securing at least circumstantial evidence of their relation, but with only partial success. However, since the numerous currant bushes which died following inoculation with mycelia obtained from the three types of spores all developed the same spores and in the same order as they occurred in blighted plantations, it seems evident that they are spores of the same fungus.

The Dothiorella-type of spores and the ascospores are most abundant during June and July in botryose stromata borne on

stems which blighted during the preceding season. Infections occur most commonly during the latter part of June and July; but the *Macrophoma*-type of spores develop only on the young succulent shoots soon after they are killed by direct infection or invasion.

Since no infections were found to occur until the last days of June and early July, although large quantities of viable spores are present in early June and some were shown (by means of the starch test) to have been distributed on leaves and young shoots at the time, it seems possible that the seasonal stage reached by the host about the first of July may facilitate infection. From the numerous inoculations attempted at various times with the different spore-forms without wounding the host it seems that the highest percentage of infection (though that was usually very low) resulted during the same seasonal stage of the host. Possibly the changes occurring in the host during the transition from active elongation-growth to the stage of maturation about the first of July are favorable to infection; but the only evident advantage seems to consist in the dying of the primary cortex, thus exposing the basal ends of petioles to infection. However, since most infections apparently take place at the petioles, that may be of some importance.

The manner of spore-dissemination was not determined, but it seems that the exuded spores may be distributed by the wind, and that small beetles (*Psenocerus supernotatus*) which eat large quantities of the sporulating *Botryosphaeria stromata* during late May, June and early July may be instrumental not only in their dissemination, but also in inoculating the host, for since the *Psenocerus* larvæ are borers in currant stems, the mycophagous imagines of necessity oviposit on those stems.

That the blight caused by *Botryosphaeria Ribis* may be reduced or controlled by pruning blighted plantations in May and burning the prunings before the end of the month, seems deducible from the life history of the fungus and the seasonal history of the disease and host.

The smaller stylosporlic stromata of *B. Ribis* resemble those of *Dothiorella ribicola* Ellis and Barth., but the pycnidia of the former are larger and its spores are nonguttulate and usually of greater size, while the spores of the latter are 2-4 guttulate. However, the stylosporlic stromata, pycnidia, and spores are apparently much like those of *Dothiorella Ribis* (Fuckel) Sacc., yet the latter is said to belong to *Diaporthe Strumella*.

REPORT
OF THE
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REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

OBSERVATIONS ON SCREENING CABBAGE SEED BEDS.*

W. J. SCHOENE.

SUMMARY.

1. This bulletin gives the results of practical tests with cheese-cloth for the protection of cabbage seed-beds against insect injuries.

2. The important insects attacking seedlings are the turnip flea-beetle, *Phyllotreta vittata* Fab., which injures the leaves of the young plant; and the cabbage-maggot, *Pegomya* spp., which attacks the under-ground portion of the plant.

3. Cheesecloth conserves the moisture, increases the temperature, and in the early season furnishes more congenial conditions for growth.

4. Plants raised under cloth start sooner, grow faster, and obtain the desired size a week or ten days earlier than plants in the open.

5. The experiments show that screening completely protects the seedlings from maggot injury; also that certain grades of cheese-cloth will prevent injury by flea-beetles.

6. The experience of four years has shown that the use of cheese-cloth is entirely practicable. In experiments in protecting plants, the cost of screening ranged from 6 to 20 cents per thousand.

INTRODUCTION.

The cultivation of late cabbage is an important industry in central and western New York. In general, it is a good cropper and, while prices are subject to considerable fluctuation, late cabbage is one of the most profitable of field crops. The chief difficulty in the cultivation of late cabbage is the growing of seedlings. This trouble is largely due to injuries by insects, though the methods practised in growing seedlings, and unfavorable weather are contributory factors. The important insects attacking the seed-bed are the turnip flea-beetle and the cabbage-maggot. The number of plants destroyed in some years is so large that farmers are not able to grow the seedlings necessary for their plantings.

An effort to protect seed-beds from injury by root-maggots was made by the Station in 1906, and in 1907 a comprehensive experi-

* A reprint of Bulletin No. 334. February, 1911.

ment was undertaken at Seneca Castle to test the practicability of screening in comparison with various protective and remedial measures. Growers were also urged to test on a small scale the value of screened frames under their own conditions. The first year's test of screening was generally very successful, and in Bulletin 301, in which the results were reported, the use of cheesecloth to protect seedlings was suggested for those who had failed by their own methods. Since the first experiment practically all of the growers in this immediate locality have adopted this method of protecting at least a part of their plantings. This practice has now been tried for four years and, while there have been some failures to grow plants under cheesecloth, there have been many reports of success. The observations recorded in this bulletin were made to determine the cost of screening and to show what cabbage growers have accomplished in protecting their seedlings.

CONDITION OF SEED-BEDS ABOUT SENECA CASTLE DURING THE PAST
FIVE YEARS.

In the season of 1906 many, if not most, of the seed-beds about Seneca Castle were destroyed by the cabbage-maggot. Some farmers made a succession of plantings during the latter part of April and May in the hope that some of the plants would escape injury, and then had difficulty in obtaining enough sets for the fields that had been prepared. In 1907 a few growers used screens for the protection of their beds, but the open beds, generally, were in no better condition than those of the previous year. During 1908 and 1909 the injury by maggots was much less than in the preceding years, although numerous reports of damage reached the Station. Also during the former year there occurred some losses by flea-beetles. The number of cabbage growers in this immediate locality who have adopted the use of cheesecloth to protect at least a portion of their plantings has increased each season, so that in 1910 a large proportion of the plants were started under screens. At the same time the injury by the cabbage-maggot has been less than in any previous season during our observations. Wilted plants were found in a few open beds and slight root injury was common in such plantings, but there were no reports of seed-beds being destroyed, such as occurred in preceding years. This variation in the amount of injury may be due to the

dry weather during the past two seasons, or to parasites, or to the unusually early spring of this year which may have brought the insects out of the ground ten days or two weeks before the cultivated plants were up. Under such conditions the maggot-flies would seek other food plants on which to deposit their eggs. It is also possible that the continued use of cheesecloth has interfered to some extent with the normal activities of the insect in this locality.

SEED-BED PRACTICES.

It is customary to select for the seed-bed a level, well drained spot of rich, loose soil. This is put in good physical condition by frequent tillage and the application of manures. Also, commercial fertilizer is used in amounts varying from three hundred to two thousand pounds to the acre. The seed is sown during the latter part of April or early in May. A week or more is required for germination and from five to ten weeks for the plants to make the desired growth. Generally the growers prefer a seedling ten to fourteen inches long, with the main stem as large as a lead pencil. The work of transplanting the seedlings to the field is performed during the latter half of June or the first week of July. Such varieties as All Head Early and All Seasons are usually set during June and the cabbages are cut in September, while Danish and other late varieties are generally planted later and the crop is harvested during late October or early November.

PRINCIPAL INSECTS OF SEED-BEDS.

TURNIP FLEA-BEETLE.

The turnip flea-beetle, *Phyllotreta vittata* Fab., appears in great numbers about May 15th, the exact date varying with the season. The same weather conditions that attract the flea-beetles from their hibernating quarters are also favorable to the germination and growth of the wild mustard, which is a common food plant for this insect. It seems, too, that for cabbage plants to obtain the size desirable for transplanting, the seed must be sown during the latter part of April or the first two weeks of May. Thus it happens now and then that the young cabbage seedlings appear simultaneously with the starved flea-beetles. In feeding, the beetles gnaw round holes which, in the cotyledon of the cab-

bage, are uniform in size and shape and reach only to the lower epidermis. If the young plant is attacked by the flea-beetles before the second and third leaves are well started, it is stunted if not killed. The cotyledon is rather thick and fleshy; and it appears that the evaporation from the cut surface is more than the plant can withstand during this period. The time that the young plant is liable to serious injury by the beetles varies with the season, but usually there is a period of five to seven days. Later injury to the foliage is not so important.

During the past five years the larvæ of the flea-beetle have been observed working at the roots of cabbage seedlings only in 1908. The weather was unusually dry during May and June of that year and the plants made a very poor growth. The absence in some seed-beds of injury by the cabbage-maggot made it possible to observe the work of the flea-beetle larvæ. In this case the underground stems of many plants were entirely eaten out so that only a part of the epidermis was left. In other plants the larvæ had chewed a furrow or channel extending longitudinally through the cortex. It is probable that the larvæ are present about the roots of cabbage every year, their work being obscured by the more prominent injury of the cabbage-maggot. Many examinations of the roots of mustard and other weeds and of cabbage roots seem to indicate that the mustard is the important food plant and it is certain that this weed is largely responsible for the great numbers of beetles present in cabbage fields in some years.

THE CABBAGE MAGGOT.

The adults of the cabbage-maggot (*Pegomya* spp.) appear about May 15th and oviposit about cruciferous plants. The eggs are found in large numbers from May 20th to June 5th. On hatching, the larva attack either the stalk or the roots of the plant and makes a channel in the cortex by the rasping action of the hook-like mouth parts. The newly hatched larva is less than one-twentieth of an inch long, and the injury to the plant is at first slight and does not become important until the maggot is eight or ten days old. In the latitude of Geneva the maggot work becomes conspicuous about June 15th and generally the grower is not aware of the presence of the insects in injurious numbers until many of the plants are killed.

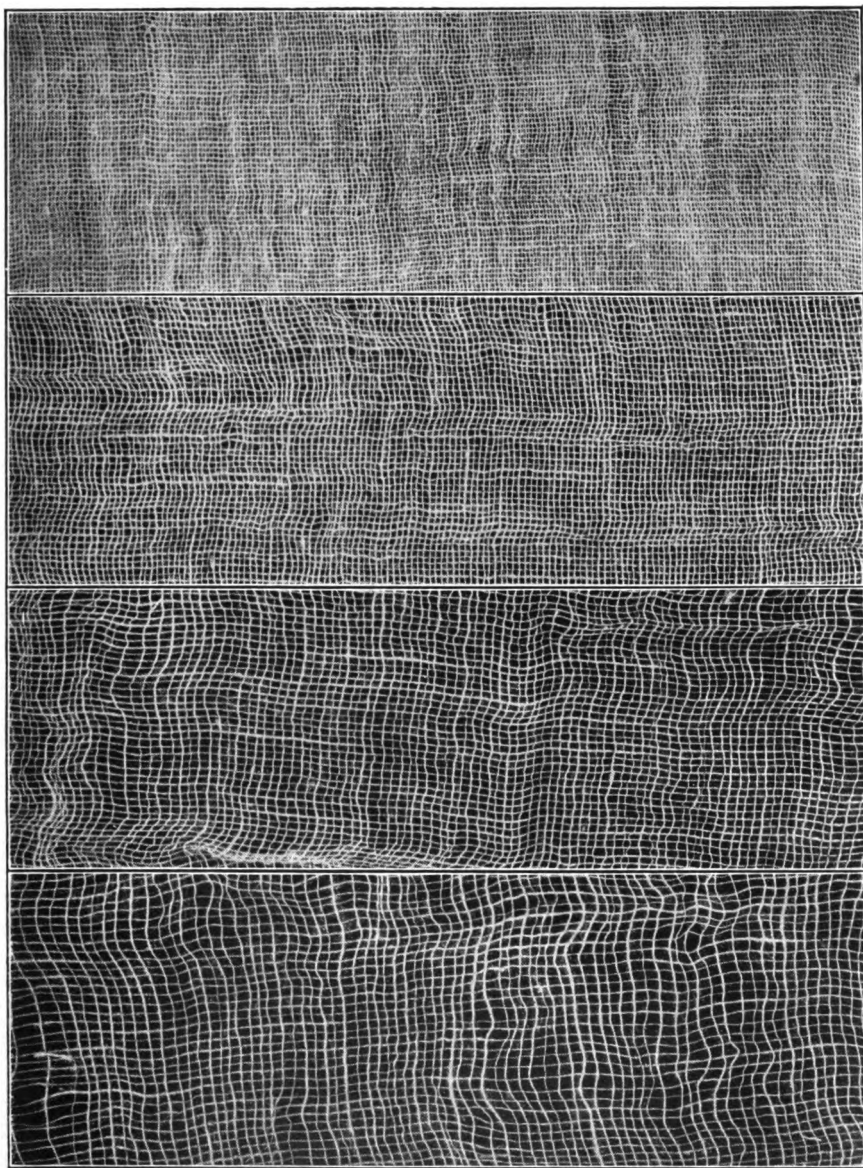


PLATE XIV.—DIFFERENT GRADES OF CHEESECLOTH: 50, 31, 21 AND 17 THREADS TO THE INCH.



PLATE XV.—UNSCREENED AND SCREENED CABBAGE SEED BEDS: INJURY IN
UPPER BED DUE TO CABBAGE MAGGOT.

The injury to the plant depends upon its size, the weather and the number of insects feeding upon the roots. The members of the cabbage family are very thrifty and, other conditions being favorable, will outgrow considerable injury. However, if the plant is small or the maggots numerous, as is frequently the case, the root is entirely destroyed. The number of seedling plants that are spoiled for transplanting in a moderate infestation depends upon the weather. A period of dry weather and a few maggots will destroy a seed-bed as quickly and completely as a bad infestation accompanied by more favorable weather conditions.

SCREENING FOR PLANT PROTECTION.

RELATION OF TIME OF GROWING SEEDLINGS TO THE PERIOD OF DEVELOPMENT OF THE FIRST BROOD OF MAGGOTS.

Throughout central New York injury by the cabbage-maggot is especially noticeable during the spring months in cabbage seed-beds, radish beds and about other cruciferous vegetables. When the maggots are numerous the injury to the roots of the seedlings is plainly indicated by the general wilting and dying of the plants under a hot sun. During cloudy and rainy weather the extent of the injury to the seedlings is not usually so apparent. Even though the underground parts may be almost completely gone, the plants under such conditions of weather do not generally succumb in large numbers, for many of them send out new roots. The eggs from which the maggots develop are deposited from May 20th to June 5th. To avoid losses by this brood of maggots it would be necessary to grow the plants after June 5th. Occasionally this has been safely done. During favorable seasons seed has been sown as late as May 30th and the plants have matured in time for transplanting by July 5th. But in most years unfavorable weather prevents the maturing of seedlings in time for transplanting unless the seed is sown May 15th or earlier. It will be seen by the accompanying chart, page 18, *that as seedlings are grown in this region the period of growth of the plant coincides with the period during which oviposition occurs and the first brood of maggots develop.* The chart clearly shows why seed-beds are so subject to attack and explains the impracticability of dodging the insect by growing new beds at varying intervals during this period.

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CHART I.—RELATION OF USUAL TIME FOR GROWING LATE CABBAGE SEEDLINGS
TO DATES OF APPEARANCE OF INSECTS IN VARIOUS STAGES.

Seeding, growth and transplanting of cabbage	Date	Time of appearance of flea-beetle and cabbage-maggot
Time of planting seed.....	April 20	Flea-beetles and cabbage-maggot flies very numerous
	" 21	
	" 22	
	" 23	
	" 24	
	" 25	
	" 26	
	" 27	
	" 28	
	" 29	
	" 30	
	May 1	
	" 2	
	" 3	
	" 4	
	" 5	
	" 6	
	" 7	
	" 8	
	" 9	
	" 10	
	" 11	
	" 12	
	" 13	
	" 14	
	" 15	
	" 16	
	" 17	
	" 18	
	" 19	
	" 20	
	" 21	
	" 22	
Growth period of seedlings.....	" 23	Eggs of cabbage flies in greatest numbers.
	" 24	
	" 25	
	" 26	
	" 27	
	" 28	
	" 29	
	" 30	
	" 31	
	June 1	
	" 2	
	" 3	
Time of transplanting.....	" 4	Maggots full grown, and period of greatest injury to seed-bed.
	" 5	
	" 6	
	" 7	
	" 8	
	" 9	
	" 10	
	" 11	
	" 12	
	" 13	
	" 14	
	" 15	
	" 16	
	" 17	
	" 18	
	" 19	
	" 20	
	" 21	
	" 22	
	" 23	
	" 24	
	" 25	
	" 26	
	" 27	
	" 28	
	" 29	
	" 30	
	July 1	
	" 2	
	" 3	
	" 4	
	" 5	
	" 6	
	" 7	
	" 8	

ADVANTAGES OF SCREENING IN CONTROL OF INSECTS AND GROWTH OF SEEDLINGS.

During the four years that screens have been employed for the protection of cabbage plants much has been learned regarding their use: (1) If the cheesecloth is carefully attached and the frame is tight, injuries by the maggot can be entirely prevented, (2) the work of the flea-beetles may be partially or wholly avoided, depending on the grade of cloth used for the screen, and (3) the screen conserves the moisture and prevents baking of the soil between seeding time and the period when the plants are of such a size as to permit cultivation.

Before the plants are of the desired size to set in the field, they are very susceptible to changes in moisture and temperature. The young cabbage plants are shallow-rooted and very tender. They do not thrive in dry or cool weather, and they are also liable to be injured by a heavy rain, lack of cultivation, and weeds. Thus the conditions of growth that surround the plant are often times of more importance than is realized by the farmer, and the great difference in the growth of the plants covered by cheesecloth and those not protected is to be attributed in part to the fact that the conditions for growth under the screen are more congenial.

EFFECT OF SCREENING ON GROWTH OF PLANTS.

In most seasons screened plants grow faster and obtain the size desired earlier than plants not screened. The difference in the size of the plants screened and not screened is very apparent in early seedlings where the seed is planted during April or the first part of May. In later plantings the difference is not so marked and now and then the plants in the open grow just as fast and make more desirable seedlings. In addition to the larger size of the plants, shade has the general effect of reducing the actual weight of dry matter stored in the plants; that is, shading makes plants

more succulent. The temperature and moisture conditions produced by cheesecloth shade are well known.¹

In general the effect of screening is to reduce sunlight and air circulation and to raise the temperature both of the air and soil. Thus we have two opposing factors: one, the shade tending to decrease the rate of growth, and the other, a higher temperature and more favorable moisture conditions, having the opposite effect.

Generally speaking, as the temperature rises there is an increase in the rate of growth, which continues until the optimum temperature has been reached. The optimum is that temperature at which a plant grows most rapidly. Beyond that point an additional rise in temperature is not beneficial and if the increase is sufficient it will cause a decrease in the rate of growth. The screening causes a rise in temperature which during the cool weather in early spring tends to increase the rate of growth of the enclosed plants; but later when optimum conditions obtain in the open an additional rise in temperature such as is produced by cheesecloth does not increase the rate of growth. Some accurate experiments in this connection were performed by Kreussler² in 1890. His work shows a general increase in photosynthesis with a rise of temperature, the maximum activity being obtained between 77° and 104° F. This is followed by a decrease as higher temperatures are reached, whereas the respiratory curve continues to rise. The difference between the gain of organic substance by photosynthesis and its loss by respiration diminishes rapidly as the temperature rises beyond the optimum. Pfeffer states³ that it is

¹ Taylor and Clark (N. Y. Sta. Bul. 246; also Ann. Rpt. 23:229) in a discussion of an experiment on shading strawberries state that the effect of the cover was to raise the temperature except on very cloudy days. The average increase for the months of May and June of 1903 was 6.1° F. at noon and 2.1° F. at 6 P. M. Also the temperature of the soil in the shaded plat was increased 7° F. The evaporation from open pans was considerably decreased, the average per day being .13 inch as against .27 inch in the check plat. Also shading was a marked benefit during the drouth of 1903. Some careful records were also made by J. B. Stewart (U. S. Dept. Agr., Soils Bul. 39) in Hartford county, Conn., in connection with shading of tobacco. These observations were made during the period of June 13th to August 5, 1905. The effect of the shade was to increase the average moisture in the soil 3.1 per ct. and the relative humidity 73 per ct., to raise the temperature of the air 1.4° F. for the period of observation, also the velocity of the wind was much reduced. Similar results were obtained by Frear (Pa. Sta. Ann. Rpt. 1905: 34, 39) in comparing shaded and unshaded conditions in 1902 at Marietta, Pa.

²Landw. Jahrb. 19:649.

³Plant Physiology, 1:337. Oxford Ed. 1900.

often the case that leaves with abundant chlorophyll under brilliant light may produce more carbon dioxide at or above 100° F. than they can decompose. The same results may be produced by longer exposure at lower temperatures. The reduction in the amount of sunlight is an important factor and probably tends to reduce the amount of dry matter stored in the plant, but it is apparent that in the early seed-beds this reduction is offset to some extent by the increase in temperature and moisture. The plant is able to utilize about 95 per ct. of the diffused light, while only 20 to 30 per ct. of the energy of direct sunlight is absorbed by the leaf, and ordinarily plants in sunlight utilize only .5 to 3 per ct. of the energy of the sun for photosynthesis. According to the very careful researches of Brown and Escomb⁴ in 1904 not quite 1 per ct. of the solar energy which falls on the leaf is employed in carbon-dioxide decomposition.

It is probable that the increase of the temperature and moisture is more important than the reduction in sunlight and that the screened plants will always make a faster growth except when the optimum conditions of light, temperature and moisture obtain in the open which rarely happens in this latitude during May and the first two weeks of June.

GRADES OF CHEESECLOTH USED TO PROTECT CABBAGE SEED-BEDS.

On Plate XIV are shown four grades of cheesecloth that have been used by cabbage growers during the past four years. These samples contain respectively 17, 21, 31 and 50 threads to the inch. All have proved effective in preventing injury by maggots, and the experience of four seasons has shown that plants can be grown successfully under cloth of these different meshes. It should be stated that the cheesecloth from which the 17-thread sample was taken easily stretches out of shape in tacking it to the frame, while 50-thread cloth is so closely woven that the plants covered with it have shown a slight tendency to be spindling. The only flea-beetle injury that has been noticed in covered beds was under the 17-thread cheesecloth. At the time of these observations other beds in the immediate vicinity covered with cloth of finer mesh showed no evidence of the work of the beetles. One of these

⁴ *Proc. Royal Soc.* 70:193, 223.

grades of cheesecloth that prevented flea-beetle injury had 28 threads to the inch so that it was a trifle more open than the 31-thread cloth shown in the illustration. Another bed that was free from attacks was covered with cloth from which the 50-thread sample was taken.

It is thought that the cloth having about 20 to 30 threads to the inch is to be preferred for the purpose of protecting cabbage seedlings. A cloth of this grade handles easily in putting it on and taking it off the frame. Also, the plants grown under such screens compare very favorably in stockiness with those grown in the open bed, and besides are not so liable to the attacks of flea-beetles.

FUNGUS DISEASES.

Seed-bed conditions are in general favorable to the development of diseases. This is especially true of the cabbage bed. The plants are tender, they grow close to each other and to the soil. The circulation of air is restricted. As the cheesecloth reduces the sunlight and air circulation and slightly increases the moisture and temperature of both the air and soil, the conditions for the growth and development of some of the common diseases are thought to be even more favorable than in beds not screened. However, there has been no serious outbreak of any disease during the past four years. The only disease that has been common is the mildew, described in the discussion of seed-bed number ten. The injuries by it have not been important in any of the seed-beds under observation.

VOLUNTEER EXPERIMENTS IN SCREENING CABBAGE SEED-BEDS.

The following descriptions of practical operations in screening seed-beds for protection from maggots were made by the writer from information obtained from growers and from repeated observations of their seed-beds.

There were no plants left purposely as checks, but usually there were a few plants at the end of the rows outside of the frames, and in several instances the screened bed was only part of a large open bed. Thus it was possible to obtain notes in most instances on the relative growth of screened and unscreened plants. The estimates regarding the number of plants produced were based

largely on the number of acres planted, it being customary to set about 7,000 to 7,500 plants to the acre. These estimates were furnished by the growers. The various items of expense were figured as follows: The cost of the screen is based on the actual price paid for the cheesecloth and the probable number of seasons it would be used as estimated by the experience of the growers. The cost and period of usefulness of the lumber have been estimated at the prevailing prices for lumber, although in most cases no material was purchased for this purpose. The labor was figured at \$1.50 per day for the actual number of hours required to screen and to care for the bed after the planting of the seed.

SEED BED NO. I.

Owned by Daniel De Lea, Seneca Castle. The bed was located in a level field with slightly higher ground on the east, west and south sides and was parallel to and drained by an open ditch that was about 3 feet deep. The soil was a gravel clay loam, having somewhat the appearance of bottom land. The plat selected for the bed was 100 yards long and 6 yards wide. It was enriched with a high grade commercial fertilizer at the rate of 2,000 pounds to the acre. Three pounds of seed was sown on April 16, and on April 17 the bed was covered. Eight-inch boards were used for the frame, a day being required for four persons to build the frame and tack on the cheesecloth. The plants were weeded once, requiring nearly a day to remove and replace the screen and to weed the bed. The cover was removed June 4 and the plants were set by June 15. Enough plants were grown in this bed to set 11 acres, or about 77,000 plants, which were valued at 50 cents a thousand. The cheesecloth used to cover this bed was purchased in two lots of 300 yards each. The first cost $2\frac{1}{2}$ cents per yard and had been used for four years, and the second lot cost $3\frac{1}{2}$ cents per yard and had been used for two years.

Items of expense connected with the screening are as follows:

300 yds. cheesecloth at $2\frac{1}{2}$ cents.....	\$7 50
300 yds. cheesecloth at $3\frac{1}{2}$ cents.....	10 50
Sewing, nails, etc.	2 00
	\$20 00

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Cheesecloth, etc., usable for 5 years; cost each year.....	\$4 00
Lumber, 424 ft. at 2 cents per ft.....	\$8 48
Lumber should last 10 years; cost each year.....	85
Labor: To cover bed, 4 persons 1 day at \$1.50.....	6 00
To remove screen, 1 person $\frac{1}{4}$ day at \$1.50.....	40
To uncover bed for weeding, 2 persons $\frac{1}{2}$ day at \$1.50.....	1 50
Total cost to screen 77,000 plants.....	\$12 75
Cost per thousand to screen plants, 16 $\frac{1}{2}$ cents.	

SEED BED NO. II.

Owned by Robert Ritchie, Seneca Castle. The bed was located one mile east of the village in a low, level field, with slightly higher ground on the east, west and south sides. The soil in this plat was a productive, well-drained, sandy loam, and it was enriched with two bags of high grade commercial fertilizer, or at the rate of two tons to the acre. The bed was 100 yards long and 4 yards wide, and was surrounded by a frame of six-inch boards. Two pounds of seed was drilled on May 4, and the frame with cover was made on May 9. The east three-fourths of the screen was ordinary cheesecloth, such as has been used in all of the experiments, while the covering of the west fourth of the frame was made of bran sacks sewed together. This was replaced by regular cheesecloth on June 4, which was allowed to remain until June 20 when all the covering was taken off. The screen made of bran sacks produced more shade than cheesecloth and the plants in this part of the bed were very spindling. However, these became toughened after the cheesecloth was put on so that by time of transplanting they made good plants. Because of bad seed or poor germinative conditions a good stand of plants was not obtained. One and one-fifth days was spent in putting on and taking off the covering, and four hours were required to lay back the cheesecloth for cultivation. This was the fourth season this screen had been used and it is good for at least one more year. Five acres of cabbage were set out of this bed. The following are the items of expense:

400 yds. of cheesecloth at 2 $\frac{1}{4}$ cents.....	\$9 00
Sewing	1 00
	\$10 00

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Cheesecloth usable for 5 years; cost each year.....	\$2 00
Lumber, 312 ft. at 2 cents.....	\$6 24
Lumber should last 10 years; cost each year.....	62
Labor: To build, 1 man for 1 day at \$1.50.....	1 50
To weed, 1 man for 4 hours at \$1.50 per day.....	70
To remove screen, 1 man for 2 hrs. at \$1.50 per day.....	35
Total cost to screen 35,000 plants.....	\$5 17
Cost per thousand to screen plants, 15 cents.	

SEED BED NO. III.

Owned by W. F. Cooper, Seneca Castle. The bed was located on a clay loam soil, protected from winds on the west by an apple orchard. The ground was fall plowed and enriched with a small amount of hen manure and commercial fertilizer at the rate of 600 pounds to the acre. The seed was sown May 6 and the bed was covered four days later. The frame was made of 8-inch boards, and was 32 yards long and $7\frac{1}{3}$ yards wide. The cover was removed about June 12 and the plants were set June 20. The bed was not weeded until after the screen was removed. Three-fourths of a pound of seed was used and enough plants were pulled to set four acres, or 28,000 plants, valued at \$14. The screened portion was part of a larger bed, one-half of which had been planted with a mixture of cabbage and radish seed. The maggot injury in the unscreened portion was such that more than half of the radishes were unfit for use and most of the cabbage seedlings showed some root injury.

The items of expense connected with the screening are estimated as follows:

235 yds. cheesecloth at $3\frac{1}{2}$ cents.....	\$8 22
Sewing	50
	\$8 72
Cheesecloth usable for 4 years; cost each year.....	\$2 18
Lumber, 160 ft. at 2 cents.....	\$3 20
Lumber should last 10 years; cost each year.....	32
Labor in erecting, $\frac{1}{2}$ day for 1 person at \$1.50.....	75
Two hours to take down.....	30
Cost to screen 28,000 plants.....	\$3 55
Cost per thousand to screen plants, $12\frac{1}{2}$ cents.	

SEED BED NO. IV.

Owned by G. F. Millart, Geneva, R. F. D. The bed was located on a small knoll fully exposed to the west winds. About three-fourths of a bag of fertilizer, which is about 750 pounds to the acre, and a load of hen manure were applied to the bed. The seed was sown May 6, in rows 9 inches apart. There were 31 rows, 76 yards long. On May 7 a frame of 8-inch boards was built around the west 50 yards of the bed and covered with cheesecloth, making a bed 8 yards wide and 50 yards long. The screen was removed June 7, after it had been on for 30 days, and the bed weeded for the first time. A careful examination of this bed was made June 13. The whole bed was practically free from injury by maggots and flea-beetles, and the plants had made a good growth, the only difference being that the screened seedlings were twice as large as those grown in the open. The plants were set in the field June 14. To build the frame and put on the screen required two men for one-half day, and to take it off, one man for two hours. The screen had been used for three seasons and can probably be used for one or two more years. The items of expense are as follows:

400 yds. of cheesecloth at 2½ cents.....	\$10 00
Sewing	1 00
	\$11 00
Cheesecloth usable for 4 years; cost each year.....	\$2 75
235 ft. lumber at 2 cents per ft.	\$4 70
Lumber should last 10 years; cost each year.....	47
Labor to build, 2 men at \$1.50, ½ day.....	1 50
Labor to take down, 1 man 1/5 day at \$1.50.....	30
Total cost to screen 42,000 plants.....	\$5 02
Cost per thousand to screen plants, 12 cents.	

SEED BED NO. V.

Owned by L. D. Knapp, Seneca Castle. The bed was a small one, and though some of the particulars regarding the time of planting have not been obtained, the information given by Mr. Knapp is interesting as it shows the ability of the young cabbage

plant to thrive under adverse conditions. In this bed there was no supporting frame. The cheesecloth was simply laid on the bed, being held at the sides and ends by stones placed along the edges.

The bed was located in the garden on a fertile spot of soil immediately behind the barn, and it was protected to some extent from the north and west winds by the barn and an orchard. A pound of seed was sown in a space 7 yards wide by 18 yards long and a piece of cheesecloth large enough to cover the plat was laid over it on the ground. Thus the plants supported the weight of the screen, which caused some of them, especially those near the margin, to grow crooked. This tendency was checked to some extent by removing the cloth about two weeks before setting time, or a little sooner than is customary. The only expense connected with the screening of this bed is the wear and tear of the screen. There were 20,000 plants taken out of the bed. The cost of screening the bed is as follows:

126 yards of cheesecloth, at $3\frac{1}{2}$ cents.....	\$4 41	
Sewing	50	
	\$4 91	
Cheesecloth usable for 3 years; cost each year.....		\$1 63
Total cost to screen 20,000 plants.....		\$1 63
Cost per thousand to screen plants, 8 cents.		

SEED BED NO. VI.

Owned by O. W. Winburn, Seneca Castle. The bed was located on a high piece of ground that sloped gently toward the east. The soil was a sandy loam. The plat was covered with two pieces of cheesecloth placed side by side, one 4 by 72 yards, and the other 4 by 65 yards. The screen was supported by a frame of 8-inch boards that enclosed the bed and also by a strip running through the bed to which one side of each of the two coverings was attached. The seed was sown on May 7th and the canvas was applied May 17th just as the plants were coming through the ground. The screens were removed June 7th and the plants were set between June 13th and June 18th. An examination of the bed was made June 13th, and at this time some of the plants were

small and appeared as if the soil was lacking in fertility. The roots of some of these seedlings had been injured by millipedes and wire worms which accounted for their small size. In general the plants under the cheesecloth were about twice as large as those outside. The seed had been drilled in rows six inches apart, and there were altogether forty-eight rows with an average length of sixty-eight and one-half yards. Out of the bed, 95,000 plants were taken, and it was estimated that millipedes had caused a loss of fifteen to twenty thousand. One day was required for two persons to put on the screen and two hours to take it off. The bed was weeded once, requiring three hours for two persons to remove and replace the screening. One strip of cheesecloth had been in use four years and the other for three years. Their cost was two and one-fourth and three cents per yard, respectively, and Mr. Winburn states that the oldest can still be used for two or three years.

The items of expense connected with the screening are as follows:

288 yards cheesecloth, at 2¼ cents.....	\$6 48	
260 yards cheesecloth, at 3 cents.....	7 80	
Sewing	2 00	
	\$16 28	
Cheesecloth usable for 3 years; cost each year.....		\$2 71
Lumber, 450 feet, at 2 cents.....	\$9 00	
Lumber should last 10 years; cost each year.....		90
Labor: To build frame and cover and to remove same—1½ day for 2 men, at \$1.50 per day.....		3 60
To remove cover for weeding, 3 hours for 2 persons.....		90
Cost to screen 95,000 plants.....		\$8 11
Cost per thousand to screen plants, 8½ cents.		

SEED BED NO. VII.

Owned by T. C. Hays, Seneca Castle. The bed was located on a level strip of ground a few yards east of the village of Seneca Castle. The soil was a rich, clay loam and was fertilized by an application of barnyard manure. The part of the bed covered with cheesecloth was 90 yards long and four yards wide. The seed was drilled in on April 21st and the frame was built and covered

the next day, five hours being required for the operation. The frame was made of 2 by 4's and the canvas supported by wires stretched from end to end of the bed. This is the fourth year the canvas had been used and with slight repairs will be good for one more year. A hand cultivator was run through the bed once while the screen was attached, and once just after the screen was removed. One-half day was required for two persons to take off the screen for the purpose of cultivating the bed. The screen was removed June 8th and the plants were set on June 17th. On June 13th the plants of the screened bed were about three times the size of those grown outside. The roots of a large percentage of the plants in the unscreened part of the bed had been injured, many of the fibrous roots had been destroyed and new fibers were forming, and the plants were generally uneven in size, and a few of them were wilting.

The screened portion produced about 30,000 cabbage seedlings, of uniform size, and with well-developed roots.

The items of expense connected with the screening are as follows:

360 yards cheesecloth, at 2½ cents.....	\$9 00	
Nails, wire and sewing.....	1 00	
	\$10 00	
Cheesecloth usable for 5 years; cost each year.....		\$2 00
Lumber, 376 feet, at 2 cents.....	\$7 52	
Lumber should last 10 years; cost each year.....		75
Labor: Time to cover, 5 hours for 2 persons, at \$1.50 per day....		1 50
Time to remove for weeding, 5 hours for 2 persons, at \$1.50 per day.....		1 50
To take down		25
Total cost to screen 30,000 plants.....		\$6 00
Cost per thousand to screen plants, 20 cents.		

SEED BED NO. VIII.

Owned by Robert Ritchie, Seneca Castle. The bed was located in the village and was partially protected on the north and west by houses and orchards. The frame was 33 yards long and 5 yards wide and was made of 6-inch boards. Three-fourths of a pound of seed was drilled on April 26th and the bed was covered on

April 30th, one hour being required to put in the seed and three hours to build the frame and cover the bed. The bed was weeded once while the screen was in place, requiring one man for one-half day for the entire operation of removing the cheesecloth and cultivating the plants. The cover was taken off June 4th and the seedlings were transplanted June 8th. Enough No. 1 plants were taken from this bed to set three acres.

The expense items for the screening are as follows:

135 yards cheesecloth, at $2\frac{1}{2}$ cents.....	\$4 12	
Sewing	50	
	\$4 62	
Cheesecloth usable for 4 years; cost each year.....		\$1 15
Lumber, 114 feet, at 2 cents.....	\$2 28	
Lumber should last 10 years; cost each year.....		23
Labor: To erect and take down, 1 man $\frac{1}{2}$ day, at \$1.50.....		75
To remove cover to weed, 1 man $\frac{1}{2}$ day, at \$1.50.....		75
Total cost to screen 21,000 plants.....		\$2 88
Cost per thousand to screen plants, 14 cents.		

SEED BED NO. IX.

Owned by James A. Brewer, Seneca Castle. The bed was located on a flat field with higher ground on the east and west sides. The soil was a black, sandy loam. The seed was drilled May 14th and the bed was covered May 20th. The screen was 55 yards long and 6 yards wide and covered twenty-two rows of seedlings. The frame was made of 6-inch boards and of 3-inch boards tacked together so that it was 6 inches high. To build the frame and cover it with cheesecloth required a man for seven hours. The screen was removed June 24 and the plants were set July 1. The bed was not weeded or cultivated. Only one and three-fourths acres of cabbage were set from this bed; but plants enough were produced to set at least five acres. The condition of the bed was noted on June 10th, at which time the plants outside were about one-third the size of those under the screen. The flea-beetles had chewed the few plants outside until they were considerably injured, while those under the cheesecloth showed no punctures except a few scattered plants near the margin of the bed.

Items of expense incident to the cost of screening:

330 yards cheesecloth, at 3½ cents.....	\$11 55	
Sewing, nails, etc.....	1 00	
		\$12 55
Cheesecloth usable for 4 years; cost each year.....		\$3 14
Lumber, 183 feet, at 2 cents, \$3.66, or per year.....		37
Labor: To erect, 7 hours for 1 man, at \$1.50 per day.....		1 25
To take down, 2 hours for 1 man, at \$1.50 per day.....		30
Total cost to screen 35,000 plants.....		\$5 06
Cost per thousand to screen plants, 15 cents.		

SEED BED NO. X.

Owned by W. P. Jones, Stanley, R. F. D. The bed was located just east of a slight elevation in a black, sandy loam soil. Two bags of high-grade fertilizer were applied to the plat, which is about one and one-eighth tons to the acre. The seed was drilled and the bed covered on May 12th. The bed contained thirty-six rows, 70 yards long, the rows being six inches apart. The bed was not weeded at any time. The cheesecloth was removed June 10th and the plants were set by June 19th. The cheesecloth from which the screen was made had been purchased at two different times; one part was secured in 1907 and had been used four seasons, while the other part was obtained in 1909 and had only been used two years. Mr. Jones was of the opinion that the older cloth would do for another year. There was a considerable difference in the mesh of the different grades and it is interesting to note that at the time the screen was removed on June 10th there was very little difference in the plants that grew under the two grades of cloth. As would be expected the plants under the cloth having the closer mesh were more tender than the others. However, on transplanting both lots grew equally well. In the different parts of the bed and among some plants not screened there were a few seedlings with yellow leaves. This trouble was identified by Mr. J. G. Grossenbacher as downy mildew, *Peronospora parasitica*. Some of these plants were examined at intervals of a few days for a month after they had been transplanted. The infestation appeared not to spread in the field to other plants or to the new growth of the same plant.

To drill the fertilizer, sow the seed and put on the cheesecloth cover required one man for a day. About two hours were required to take off the screen and remove the frame. When the bed was seeded the four west rows were accidentally skipped, due to an obstruction in the drill; however, six acres were planted and there were abundant plants to set as many more, the total number of seedlings being estimated at 90,000.

The items of expense connected with the cost of screening are estimated as follows:

300 yards cheesecloth, at $2\frac{1}{2}$ cents.....	\$7 50	
200 yards cheesecloth, at $3\frac{1}{4}$ cents.....	6 50	
Sewing	1 50	
	\$15 50	
Cheesecloth usable for 5 years; cost each year.....		\$3 10
228 feet lumber, at 2 cents per foot.....	\$4 56	
Lumber should last 10 years; cost each year.....		46
Labor to build, 1 man for 1 day, at \$1.50.....		1 50
Labor to take down, 1 man $\frac{1}{2}$ day, at \$1.50.....		30
Total cost to screen 90,000 plants.....		\$5 36
Cost per thousand to screen plants, 6 cents.		

SEED BED NO. XI.

Owned by Alfred Armington and Benjamin Jones, Orleans. The bed was located on the east side of a large hill in a gravel-clay soil. Fertilizer was applied at the rate of 400 pounds to the acre, and the seed was sown on May 3d. The frame was 4 yards wide and 90 yards long, and was made of 8-inch boards. Six hours were required for two men to build the frame and attach the cheesecloth. On June 14th the plants were making good growth, but those under the screen were larger than those outside. The cheesecloth was removed July 1st and the plants were set on July 6th. The bed produced plants enough to set nine acres.

Mr. Jones says in regard to growing plants under the screen that it is the only reliable method, and that during the past five years he has always failed to grow seedlings in unscreened beds.

Expense items for the screening are as follows:

475 yards cheesecloth, at $3\frac{3}{4}$ cents.....	\$17 81
Sewing	1 00
	\$18 81

Cheesecloth usable for 4 years; cost each year.....	\$1 70
Lumber, 376 feet, at 2 cents per foot.....	\$7 52
Lumber should last 10 years; cost each year.....	75
Labor to erect and take down, 6¾ hours for 2 men, at \$1.50 per day	2 02
Total cost to screen 63,000 plants.....	\$7 47
Cost per thousand to screen plants, 12 cents.	

SUMMARY AND CONCLUSIONS.

The experience of farmers about Seneca Castle, during the past four years, has shown conclusively that the use of tight frames, covered with cheesecloth, will entirely prevent injury by the cabbage-maggot. The use of certain grades of cheesecloth will help to prevent injury by the flea-beetle. Plants raised under cloth grow faster during most seasons and attain the size desired for transplanting about ten days or two weeks sooner than plants grown in open beds. The extra cost of screening plants in these eleven seed-beds, by ten different growers, ranged from six to twenty cents per thousand plants. These figures are based on very conservative estimates of the number of plants produced, with full allowance for the various items of expense. In the opinion of many of the growers who have used screens for several years, the extra cost of the cheesecloth is more than met by the saving in seed. The plants grown under screens have good roots so that they start quickly when transplanted; while plants grown in the open are liable to suffer a varying amount of root injury, even in years when there is only a mild infestation of maggots. In addition some cabbage growers prefer to screen their beds because they may obtain sets earlier than can be grown in open beds. Usually the cabbages that are set early are the first harvested, and it happens frequently that the first sales in the fall bring a better price than the regular crop.

The screened plants are more tender than those not screened, but experience has shown that by removing the cover a week or ten days before transplanting, the seedlings become sufficiently hardened so that there is very little difference in the growth of the sets in the field.

SUGGESTIONS ON SCREENING CABBAGE SEED-BEDS.

The seed-bed should be located on a fertile, well-drained soil, where there can be no accumulation of water or washing under the frame by rains. It is also desirable to locate the bed on land known to be free from weeds, and injurious insects such as wire worms and white grubs. The ground should certainly be free from the disease known as club-root. The soil should be thoroughly cultivated so that it is in good physical condition at seeding time. It is customary to apply liberal amounts of high grade commercial fertilizer. The seed should be drilled rather thickly, in rows six or eight inches apart. When the early varieties of cabbage are to be grown, the seed should be planted during the first part of May or even earlier, whereas such varieties as Danish should be planted about May 15th. Before the seed is drilled, the corners of the bed should be staked, so that the frame can be built and the cheesecloth applied before the plants come up. This is important as the cloth prevents the soil from baking and conserves the moisture; also if the screening is delayed until after the plants come up, the plants are subject to injury by the flea-beetle. Six-inch boards will serve for the frame though some growers use eight and ten-inch boards with satisfaction. The cloth should not sag and rest on the plants. This may be prevented by stretching several lengths of wire from end to end of the bed. The wires should not be more than four or five feet apart. The wire can be supported on stakes to which it is held by staples. It is preferable that galvanized wire and staples be used as rusty wire wears holes in the cloth at the point of contact. All openings under the frame, due to unevenness in the soil, should be filled by banking the earth against the boards. To harden the plants so they will not wilt beyond recovery when set in the field, the cheesecloth should be removed a week or ten days before transplanting. It is well to examine the soil about the plants at intervals of several days after they have been uncovered to ascertain if eggs are being deposited. If the eggs are numerous the plants should be transplanted as soon as possible, the earth being shaken from the roots, which will dislodge most of the eggs or young maggots. When the plants have reached a desirable size they should be transplanted, as they are liable to grow too long and spindling.

REPORT
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REPORT OF THE DEPARTMENT OF HORTICULTURE.

NEWER VARIETIES OF STRAWBERRIES, AND CULTURAL DIRECTIONS.*

O. M. TAYLOR.

SUMMARY.

This bulletin gives a report on fifty varieties of strawberries, many of them recent introductions, which fruited on the Station grounds in 1909 and 1910. During each year the local climatic condition of rainfall was decidedly unfavorable during the fruiting season. This must be borne in mind in interpreting the results. The value of a variety for any locality can be determined only by actual trial under the conditions existing in that place.

The yield of all varieties was much smaller than in previous years owing to drought, which affected both the number of plants produced and quantity of the fruit. Relative differences, however, were very marked. Among the thirteen varieties producing plants in great numbers were Bessie and Nonsuch, while Battenburg and First Quality are good examples of the eighteen kinds producing few plants. Thirty-six varieties were intermediate in yield, with the remainder, fourteen in number, distributed equally between the most and least productive kinds.

Owing to the two seasons being unfavorable to the development of strawberry diseases no records of value could be made concerning resistance to disease. The health of a plant bears a close relationship to its productiveness. Selection of varieties practically immune to fungus or insect troubles is a phase of plant-breeding receiving considerable attention at the present time with both tree and small-fruits.

Knowledge regarding the sex of a variety is important. Failure of crop would undoubtedly result through the planting of

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any of the eleven imperfect-flowering kinds if set by themselves with none of the perfect-flowering varieties nearby to fertilize the blossoms.

Late spring frosts frequently cause the destruction of many blossoms of the early blooming varieties and in some parts of the State it is impossible to grow those kinds with much profit. Three of the earliest blooming varieties described, however, Mascot, Parcell Early and Superior are of sufficient merit in other characters to make them desirable for a test even in the colder sections of the State.

In previous tests of varieties there has been a dearth of promising early kinds. This condition is reversed in the test under discussion, however, and among the ten early varieties described are Early Ozark, Highland, Mascot, Monroe and Parcell Early which appear worthy of more extended trial.

Severe drought during the ripening season decreased both yield and size of fruit. There were marked differences, however, between the varieties, especially in size. Eight of the twelve promising kinds produced fruit of good size throughout the season.

As is usually the case the number of promising kinds was comparatively small. Thirty-eight of the fifty varieties were discarded and twelve appeared to be worthy of more extended trial. Of these twelve kinds, Highland, Kittie Rice and Sherman are imperfect-flowering; Early Ozark and Battenburg were unusually productive; Deacon is a perfect-flowering mid-season variety of high quality; Mascot, a tart berry, although not of largest size, appears productive for an early kind and the glossy surface is attractive when the numerous, raised seeds are not too conspicuous. Parcell Early, the first to ripen in 1910, is worthy of test on account of its early season and productiveness, but it requires a good supply of nitrogen to secure best results; *Stall No. 1* appears to be a seedling of merit, with good plant habits and of high quality for a mild berry.

The cultural directions which follow description of varieties are not intended to contain full detailed instruction on this subject but rather are suggestive of some methods worthy of consideration. The operations must necessarily vary in different places to meet the local conditions.

INTRODUCTION.

Two seasons have passed since the last bulletin (No. 309) of this Station on Varieties of Strawberries was issued. Since then, in 1909 and again in 1910, a number of the newer varieties have fruited, also a few seedlings sent to this Station for testing. The object of this bulletin is to report on these varieties, grown on rather heavy clay loam at Geneva.

The plants were spring-set, at a distance of one and one-half feet in rows three feet apart, on heavily manured, well drained clay loam. Clean culture was given during the summer, the first runners were encouraged to root as quickly as possible, and the blossom-clusters were kept picked off the first season up to the middle of July. As soon as the ground was frozen, the plants were covered with a mulch of coarse stable manure through which the plants grew the following spring. The cultural treatment was the same in every detail for all varieties.

In the description of varieties the source of the plants received is first given followed by brief notes in regard to their history, characteristics of plant and fruit and the apparent value as shown under the conditions at this Station. These results do not determine the value of any variety for the State at large or for nearby localities which have different environments. They indicate what may be expected of such varieties when fruited under similar conditions.

Of all the small-fruits the strawberry appears to be one of the most susceptible to changes of environment not only due to a different locality but also to widely varying climatic changes. This condition is probably due in large part to the comparatively small root-system of the plant, which is quickly affected at times by unfavorable weather, especially as the ripening season approaches. The seasons of 1909 and 1910 were not only dissimilar, but also the widest variations existed during the same season in different parts of the State.

It is probable that of all the problems confronting the strawberry grower, the question of the water supply is of greatest im-

portance. In 100 pounds of the ripe fruit there may be from 87 to 94 pounds of water¹. There appear to be no reliable data at hand showing the amount of water used by the plant especially during the ripening season; the amount must be large owing to the rapid transpiration from the extensive leaf-surface and if not available the lack is quickly indicated in a decreased yield. The table which follows shows clearly that at Geneva at least, there must have been, during the years 1909 and 1910 a great lack of moisture during the strawberry season from June 15 to July 15 as the average monthly rainfall for that time was only 1.42 inches as compared with a similar average of 4.8 inches for the same month of the preceding five years.

RAINFALL AT GENEVA DURING STRAWBERRY RIPENING, 1904-1910.

DATE	1904	1905	1906	1907	1908	1909	1910
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
June 15 to July 15	5.37	8.43	4.81	2.87	2.52	1.50	1.34

NOTES ON VARIETIES.

Productiveness.—On account of the small amount of rainfall at fruiting time the yield of all varieties was much less than in previous years. Relative differences, however, were observed and the rating is given in the description of each variety. Of the fifty varieties tested, seven were very productive and seven were unproductive. The following varieties include only the extremes in productiveness.

VERY PRODUCTIVE

Battenburg
Clifton
Early Ozark
Iowa
Paul Jones
Rockhill No. 10
Swedenberg

UNPRODUCTIVE

Americus
Glastonbury
Goree
Irena
Red Bird
Rockhill No. 7
Rockhill No. 9

¹ Handbook of Exp. Sta. Work, U. S. D. A., O. E. S. Bul. 15:388. 1893.

Resistance to disease.—As might be expected, plants of nearly all varieties were unusually healthy. Mildew and leaf-blight develop slowly, if at all, under unfavorable conditions and the prolonged period of dry weather retarded the rapid spread of these diseases. On this account a large proportion of varieties, forty-three in number, showed no indication of fungus trouble while only seven appeared susceptible to such attacks. During seasons of more frequent rainfall, these results would doubtless be materially changed.

Vigor of plants.—Productiveness and resistance to disease are closely associated with vigor, yet the most vigorous plants are not always the most productive. Of seven varieties, Clifton, Dixon, Early Ozark, Kevitt Wonder, Manhattan, Matthew Crawford and *Rockhill No. 6*, all characterized by a comparatively low-growing habit, the first and third were among the most productive varieties under test. Two of the most vigorous varieties, Bessie and Nonsuch, were very productive, while Highland, ranking with them in vigor, proved considerably less productive. The fact must not be lost sight of that the amount of nitrogenous fertilizer in the soil affects the character of plant-growth. In the tests under discussion, however, the amount and kind of plant food supplied was the same for all varieties.

Plant-makers.—There are wide differences in the ability of varieties to reproduce themselves through the development of new plants from runners. With some kinds the plants are produced in such large numbers that a most serious condition of overcrowding results unless the original plants be given more room or those considered unnecessary be cut out. Some kinds, however, produce few runners and the distance of planting should be closer to avoid loss from unoccupied ground. Last season a single plant at the Station developed forty-seven plants while an equally vigorous one of another variety produced but one plant. Thirteen varieties described in this bulletin produced plants in great numbers while eighteen kinds developed but few runners.

Sex of flowers.—In the planting of perfect-flowering varieties, those in which the stamens, as well as the pistils, are present, no thought need be given to pollinating varieties, but the imperfect-flowering kinds, those with no stamens in the blossoms, must have plants of perfect-flowering varieties growing nearby to provide for fertilization of their blossoms. The following varieties were imperfect-flowering:

VARIETIES HAVING IMPERFECT FLOWERS.

Highland	Paul Jones
July	Red Bird
Kittie Rice	Salisbury
Labell	Sherman
Moyer	Wooster
Orphan	

Blooming season.—In the colder sections of this State and in exposed locations some of the early blooming varieties may be severely injured by late spring frosts. Some protection may be secured by holding back the growing season somewhat by a covering of mulch as indicated under cultural directions. Occasionally it may be desirable, however, to select varieties that bloom later than others. The season of bloom is given in the description of varieties. Four varieties, Mascot, Parcell Early, *Riehl No. 10* and Superior were very early bloomers while Dixon, July, Orphan and Outlander were among the varieties which opened their blossoms latest in the season.

Season of ripening.—The market to be supplied has an important bearing on the selection of varieties with regard to time of ripening. In one location an early market is most profitable while in another place late varieties may be most in demand. Weather conditions materially change the date of ripening in different years and also lengthen or shorten the season during which profitable pickings may be made. There can be no marked line of division between some varieties as they blend one into another. The divisions must therefore be arbitrary and the varieties may not follow the same order each season. Those described have been

grouped into early, mid-season, or late, the two extremes being listed as follows:

SEASON EARLY

Early Ozark
Highland
Irena
Mascot
Monroe
Parcell Early
Red Bird
Rockhill No. 9.
Swedenberg
Wooster

SEASON LATE

Americus
Greenwood
Heritage
Labell
Manhattan
Matthew Crawford
Nonsuch
Orem
Orphan
Outlander
Salisbury
Silver Coin

Size of fruit.—One of the requirements of varieties for commercial purposes is fairly good size. It is not sufficient that the fruit ship well and be of attractive color. A wide range exists among the different varieties in regard to size. Some kinds uniformly run small; others produce large fruit at first but rapidly drop in size as the season progresses; still others retain their size fairly well throughout the season. Fruit averaging above medium usually ships better than berries of largest size. At each picking the berries were rated and the following is a list of those varieties retaining good size fairly well throughout the season.

FRUIT OF GOOD SIZE THROUGHOUT THE SEASON.

Battensburg
Deacon
Dicky
Early Ozark
Fendall
First Quality
Glastonbury
Gray Dollar
Monroe
Myer

Nonsuch
Orem
Orphan
Outlander
Parcell Early
Paul Jones
Rockhill No. 11
Sherman
Stall No. 1
Wooster

Desirable kinds.—The final selection of the best varieties to grow is one of the most important and most difficult of all the

subjects connected with strawberry growing. Habits of both plant and fruit must receive careful scrutiny not only once but at different times during the season. Even then we know that some of these characters are not constant in different environment, and the safest method to follow is the trial under the conditions existing in the locality in which the plants are to be grown. The following list of varieties is therefore only suggestive. It includes the most promising of the kinds fruited in 1909 and 1910 under but one set of conditions. It is not expected that they will do equally well in all localities. They, however, appear to combine most fully, although not perfectly, the various requirements that go to make a desirable berry. It will be noted that the list includes those of highest quality. A variety may be productive, of good size and color, but if poor in quality, it is undesirable.

VARIETIES HAVING MANY DESIRABLE CHARACTERS.

Battensburg	Mascot
Deacon	Monroe
Early Ozark	Parcell Early
First Quality	Sherman
Highland	Stall No. 1
Kittie Rice	Superior

DESCRIPTION OF VARIETIES.

Americus.—*Rockhill No. 2.* (Harlow Rockhill, Conrad, Ia.) A seedling of Louis Ganthier crossed with Pan-American, originating in 1905 with Mr. Rockhill. Introduced in the fall of 1910 by several nurserymen and individual growers.

Plants few, below medium in size, of average vigor, healthy, unproductive. Leaves of medium size, thick, dark green; leaf-stems short, of average thickness. Flowers perfect. Calyx small, flattened or slightly depressed. Seeds raised. Fruit ripening late; of medium size, roundish, light red, somewhat glossy; apex obtuse; flesh medium in juiciness, firm, mild subacid; of fair quality.

The plants lack in vigor and productiveness and the fruit, although a good shipper, is inferior in size, color and flavor.

Battensburg.—(A. T. Goldsborough, Wesley Heights, Washington, D. C.). Originated by Mr. Goldsborough and introduced by him in 1906. A seedling of Royal Straight Flush crossed with Fujiyama.

Plants few, of medium size and vigor, healthy, very productive. Leaves blunt at the apex, of average size, dark green; leaf-stems intermediate in length and thickness. Flowers perfect, medium in season of bloom; petals

obovate, usually 5 to 8 in number; stamens numerous. Calyx large, flattened or depressed, leafy. Seeds raised, conspicuous. Fruit maturing in mid-season; large, wedge-shape varying to roundish-conic, the surface furrowed and irregularly roughened, rather attractive light red, glossy; apex obtuse; flesh well colored, juicy, firm, sprightly, somewhat tart; of good quality.

Plants although very productive make but few runners and should be set closer than most varieties; fruit furrowed and variable in shape in the first pickings, improving later, retaining large size fairly well throughout the season; worthy of more extended trial.

Bessie.—(D. B. Boomhower, Greenville, N. Y.) A chance seedling found on the farm of Mr. Boomhower in 1899, not yet introduced to the trade. Thought to be cross between Haverland and Bert.

Plants very numerous and vigorous, large, somewhat subject to attacks of mildew and leaf-blight, productive. Leaves large, of medium thickness and color; leaf-stems long, of average thickness. Flowers perfect, unusually large, often $1\frac{1}{2}$ inches across; petals obovate, tapering to short, narrow claws, 7 to 8 in number; stamens numerous, long. Calyx of medium size, flattened, reflexed. Seeds small, numerous, sunken. Fruit maturing in mid-season; above medium size but variable, irregular in shape ranging from conic to wedge, light red, dull and rather unattractive; apex obtuse; flesh light colored toward the center, very juicy, not very firm, mild, sweet, slightly aromatic; of good quality.

The large flowers are characteristically conspicuous above the foliage at blooming time; plant-habits good but color of fruit too dull and unattractive; a poor shipper; does not retain size in later pickings.

Clifton.—(J. K. Losee, Elnora, N. Y.) Found in a trial bed of several varieties by Mr. Losee in 1905 and introduced by him in 1908. Parentage unknown.

Plants of medium number and size, low-growing in habit, healthy, very productive. Leaves of medium size and thickness, dark green, with heavy pubescence; leaf-stems short, of average thickness. Flowers perfect, nearly $1\frac{1}{4}$ inches across; petals roundish, 5 to 6 in number; stamens numerous of medium length. Calyx above medium in size, depressed, somewhat reflexed. Seeds small, variable in position. Fruit maturing in mid-season; variable in size averaging above medium, conic or wedge-shape, medium scarlet, dull; apex obtuse; flesh of good color, juicy, firm, with rather hard core, aromatic, tart; good in quality.

Not promising as the fruit does not pick easily, is variable in size, and color is too dull.

Deacon.—(C. S. Pratt, Reading Mass.) Thought to be a seedling of Abington and Sample originating in Massachusetts. Introduced by Mr. Pratt in 1909.

Plants intermediate in number, size and vigor, healthy, moderately productive. Leaves large, thick, rather light green, with considerable pubescence; leaf-stems of average length, thick, covered with abundant pubescence. Flowers perfect, medium in season of bloom, $1\frac{1}{2}$ inches across; petals somewhat

roundish, 6 to 7 in number; stamens numerous, of average length. Calyx large, flattened or slightly raised, leafy. Seeds sunken. Fruit maturing in mid-season; large, conic or wedge-shape, sometimes slightly necked, medium scarlet, glossy, attractive; apex pointed or obtuse. Flesh well colored, juicy, firm, mild, sweet, aromatic; very good in quality.

Foliage characteristically pubescent. In the earlier pickings one of the best varieties in size, shape and color of fruit but later the color becomes duller and less attractive; retains size well throughout the season; on account of high quality worthy of further trial.

Dicky.—(C. S. Pratt, Reading, Mass.) A seedling of Marshall and Sample said to have originated with J. D. Gowing, North Reading, Mass., and introduced by Mr. Pratt in 1908.

Plants intermediate in number, size and vigor, healthy, medium in productiveness. Leaves large, medium green, rugose; leaf-stems of average length and thickness. Flowers perfect, intermediate in season of bloom, $1\frac{1}{2}$ inches across; petals nearly oblate, usually 7 in number; stamens numerous, short. Calyx medium in size, flattened. Seeds numerous, variable in position, detracting somewhat from appearance. Fruit maturing in mid-season; rather large, conic or wedge-shape, glossy, attractive medium scarlet; apex pointed, often green-tipped; flesh well colored, juicy, firm, tart, not pleasant in flavor; of poor quality.

A fairly good plant-maker but lacking somewhat in productiveness. Retains size well but is too seedy in appearance and too sour; inferior in quality.

Dixon.—(T. C. Kevitt, Athenia, N. J.) Probably a seedling of Wm. Belt originated by Emil Grafe, Rossville, Staten Island, N. Y.

Plants very few in number, small, weak, somewhat subject to attacks of leaf-blight. Leaves rather small, thick, medium green; leaf-stems short, of average thickness, covered with abundant pubescence. Flowers perfect, opening late $1\frac{5}{16}$ inches across; petals roundish, 6 to 7 in number; stamens numerous, short. Calyx large, leafy, depressed. Seeds raised. Fruit maturing in mid-season; medium to large, wedge-shape, dull, unattractive medium scarlet; apex obtuse, often green-tipped; flesh well colored, medium in juiciness, firm, tart, not pleasant in flavor, poor in quality.

Plants inferior in habit of growth, developing but few runners. Fruit does not retain size well in late pickings; a good shipper; unattractive in color and inferior in quality.

Early Ozark.—(Chas. Shull, Sarcoxie, Mo., and M. Crawford Company, Cuyahoga Falls, O.) A seedling of Aroma and Excelsior originated by Mr. Shull in 1902 and introduced by him in 1908.

Plants numerous, medium in vigor, healthy, very productive. Leaves small, of average thickness, medium green; leaf-stems intermediate in length, slender, characteristically tinged red. Flowers perfect, blooming rather early, nearly $1\frac{3}{16}$ inches across; petals roundish, 6 to 8 in number; stamens numerous, variable in length; pistil-clusters rather large. Calyx small, reflexed, depressed. Seeds intermediate in size, inconspicuous, sunken. Fruit maturing very early; above medium to medium in size, roundish-conic, glossy, attractive

dark scarlet; apex obtuse or indented; flesh well colored, very juicy, firm, subacid or pleasantly tart, high-flavored, very good to best.

Plants although somewhat low-growing are very productive and make a fairly good growth; leaf-stems characteristically tinged red. Fruit ripens very early and for a berry of its season is above the average in size and ranks high in quality. One of the most promising of the early kinds and worthy of more extended trial.

Fendall.—(Chas. E. Fendall & Son, Towson, Md.) A seedling of William Belt originating with Fendall & Son in 1905 and introduced by them in 1907 and 1908.

Plants few, intermediate in size and vigor, healthy, productive. Leaves of average size and thickness, medium green, covered with considerable pubescence; leaf-stems medium in length, stout. Flowers perfect, about 1 1/16 inches across; petals heart-shaped, 6 to 7 in number; stamens variable in number, rather short. Calyx large, leafy, raised, reflexed. Seeds large, variable in position. Fruit maturing in mid-season; large, characteristically oblong-conic, necked, attractive light scarlet; apex pointed; flesh rather light toward the center, medium in juiciness, intermediate in firmness, mild subacid; of good quality.

Plants although healthy and productive lack somewhat in vigor. Fruit characteristically elongated, retains size well throughout the season, some berries too light in color; of good quality for a mild berry. The greatest fault appears to be in shape.

First Quality.—(C. S. Pratt, Reading, Mass.) A seedling of Gandy and Sample originating with J. D. Gowing, North Reading, Mass., and introduced by Mr. Pratt in 1909.

Plants few, large, vigorous, healthy, medium in productiveness. Leaves, large, thick, dark green, rugose; leaf-stems above medium in length, thick, with abundant pubescence. Flowers perfect, intermediate in season of bloom. Calyx of average size, leafy, flattened. Seeds sunken. Fruit picks easily, maturing in mid-season; very large to large, distinctly conic, attractive, glossy, medium scarlet; apex pointed; flesh medium in juiciness, firm, mild, sweet; very good for mild berry.

A poor plant-maker and although vigorous should be set closer than most varieties. Fruit characteristically conic, picks easily, retains good size fairly well throughout the season. Attractive in color. Quality above the average for a mild, sweet berry, although lacking slightly in juiciness. Worthy of further trial.

Glastonbury.—(J. H. Hale, South Glastonbury, Conn.) A seedling of Haverland pollinated by Great Scott. Originated at Glastonbury, Conn., in 1901 or 1902 and introduced in 1907 by Mr. Hale.

Plants few in number, intermediate in size and vigor, healthy, unproductive. Leaves large, of average thickness, variable in color, rugose; leaf-stems above medium in length, of average thickness. Flowers semi-perfect, intermediate in season of bloom, 1½ inches across; petals broad-oval, 6 or 7 in number; stamens few, rather short; anthers somewhat shrivelled. Calyx of medium

size, flattened. Seeds variable in position. Fruit maturing in mid-season; large, conic, glossy, attractive medium scarlet; apex pointed; flesh rather light colored, very juicy, firm, tart and sprightly; of good quality.

A poor plant-maker and unproductive although healthy. Berries of good size and color but coarse in appearance and rather too tart for dessert purposes. Surpassed by other varieties.

Goree.—(M. Crawford Company, Cuyahoga Falls, O., and the Munson Nurseries, Denison, Texas.) An accidental seedling of unknown parentage found among plants of Brandywine on the grounds of J. W. Goree, White-wright, Texas, in 1902. Tested and propagated there until introduced by T. V. Munson & Son, Denison, Texas, in the fall of 1907.

Plants few, medium in size and vigor, healthy, unproductive. Leaves large, of average thickness, dark green, not pubescent; leaf-stems long, slender. Flowers perfect, medium in season of bloom, one inch or more across; petals roundish, usually 5 in number; stamens numerous, long. Calyx of medium size, slightly raised or flattened, not reflexed. Seeds medium in size, somewhat sunken. Fruit maturing in mid-season; medium to small, conic, sometimes slightly necked, dark crimson, glossy and attractive; apex obtuse; flesh light colored, very juicy, firm, subacid, rather high flavored; of good quality.

Plants although healthy lack somewhat in vigor, develop but few runners and are unproductive. Fruit attractive dark red, a fine shipper but too small as fruited on the Station grounds.

Granger.—(E. H. Ekey, Steubenville, O.) A seedling of unknown parentage originated in 1908 by Mr. Ekey. Not yet introduced.

Not enough plants lived to secure a good test. Appears to be a mid-season variety, fruit of which is large, conic, with pointed apex, attractive, glossy scarlet, well colored to the center, juicy, firm, pleasant subacid; of high quality. Requires further testing to determine its value.

Gray Dollar.—(M. Crawford Company, Cuyahoga Falls, O.) Originated by A. G. Gray, Pekin, Ind., and introduced by him about 1908.

Plants numerous, large, vigorous, healthy, moderately productive. Leaves rather large, thick, medium green, rugose; leaf-stems long, of average thickness, greenish. Flowers perfect, intermediate in season of bloom, 1½ inches across; petals roundish-oval, 6 to 7 in number yellowish at the base; stamens numerous, rather short. Calyx large, flattened, leafy. Seeds variable in size and position. Fruit ripening in mid-season; large, thick, wedge-shape, medium scarlet, dull; apex obtuse; flesh well colored, juicy, firm, subacid or tart, sprightly, high-flavored; very good in quality.

Except in productiveness the plant-characters are unusually good. The fruit, which matures in mid-season, is of good size and much above the average in quality but the large, leafy calyx and dull color of the berries detract from the appearance.

Greenwood.—(C. S. Pratt, Reading, Mass.) Said to have originated with Mr. S. Hill, Greenwood, Mass. Introduced by Mr. Pratt in 1909.

Plants few, above medium in size and vigor, healthy, rather unproductive. Leaves large, of average thickness, medium green, not pubescent; leaf-stems

above medium in length, thick, greenish. Flower-stalks characteristically long and slender-branched. Flowers perfect, intermediate in season of bloom, $1\frac{1}{8}$ inches across; petals roundish; stamens numerous, of medium length. Calyx of average size, flattened or raised. Seeds sunken. Fruit maturing rather late; above medium in size, conic or wedge-shape, sometimes slightly necked, light red, medium in glossiness; apex pointed; flesh rather light colored, medium in juiciness, firm, very mild, not high-flavored, sweet; inferior quality.

Plants develop but few runners, unproductive although not lacking in vigor or health. Flower-stalks characteristically long and slender-branching. Fruit, inferior in size and in desirable flesh-characters.

Heritage.—(A. J. Collins, Moorestown, N. J.) A seedling of Barton Felipe fertilized by Marshall, originated in 1902 with J. E. Heritage, Marlton, N. J., and introduced by him about 1906.

Plants few, of medium size, vigorous, healthy, productive. Leaves intermediate in size, of average thickness, light green; leaf-stems medium in length and thickness. Flowers large, perfect, $1\frac{3}{8}$ inches to $1\frac{7}{8}$ inches across; petals broadly ovate, 7 to 9 in number; stamens very numerous, long; pistil-center large. Calyx large, raised, leafy. Seeds numerous, sunken. Fruit maturing late; large, irregular oblong or wedge-shape, medium scarlet, glossy and attractive; apex pointed; flesh lighter than the surface, medium in juiciness, firm, subacid, high-flavored; very good in quality.

Habit of growth good; tendency to develop but few runners; fruit does not retain size in later pickings; inferior in shape, color and shipping quality; well flavored.

Highland.—(M. Crawford Company, Cuyahoga Falls, O.) An accidental seedling discovered by T. B. Carlisle, near Lisbon, Ohio, about 1896 and introduced by the M. Crawford Company in 1908.

Plants numerous, large, very vigorous, healthy, productive. Leaves large, of average thickness, dark green, with very scant pubescence; leaf-stems long, of medium thickness. Flowers small, imperfect, nearly 1 inch across; petals broad-ovate, 7 or 8 in number; pistil-center large; fruit-stems prostrate, branching freely. Calyx of medium size, flattened. Seeds small, deeply sunken. Fruit very early; large, conic, slightly furrowed, light scarlet, glossy and attractive; apex obtuse; flesh well colored to the center, very juicy, tender, very tart, sprightly, good for a sour berry.

Plant-characters unusually good; plants should not be crowded as they are markedly vigorous in habit of growth; unusually promising for an extra-early variety. Fruit of good size in the early pickings; well-shaped and of good quality. Worthy of test where a rather tart, very juicy, light scarlet, early berry is desired.

Iowa.—*Rockhill* No. 8. (Harlow Rockhill, Conrad, Ia.) A seedling of Senator Dunlap pollinated with Pan-American originating in 1906 with Mr. Rockhill. Introduced in the spring of 1911 by M. Crawford, Cuyahoga Falls, O.

Plants characteristically few in number, large, vigorous, healthy, very productive. Leaves intermediate in size and thickness, dark green, rugose; leaf-

stems medium in length, slender. Flowers perfect, blooming rather early. Calyx of average size, flattened or depressed. Seeds sunken. Fruit maturing in mid-season; rather large, roundish-conic, glossy, attractive light red, colors unevenly; apex obtuse; flesh well colored, not juicy, rather tender, mild, not high-flavored, subacid; of fair quality.

Plants characteristically few in number, of good vigor and unusually productive. Fruit of excellent size in the early pickings dropping rapidly as the season advances. Attractive in appearance but disappointing in flesh-characters. Not juicy nor a good shipper and low in flavor.

Irena.—(W. S. Todd, Greenwood, Dela.) Said to be a cross between Jessie and Warfield originating in Wisconsin and introduced about 1896 by W. S. Butler, Chetek, Wis.

Plants characteristically tall, light green and with rather small leaves, medium in number, healthy, unproductive. Leaves smallish, of medium thickness, not pubescent; leaf-stems long, slender. Flowers perfect, blooming medium early, $1\frac{1}{4}$ inches across; petals roundish, variable in number usually 5 or 7; stamens numerous, short. Calyx small, variable in position. Seeds large, numerous, raised or sunken. Fruit maturing very early; above medium to medium in size, wedge-shape to conic, the surface irregular and roughish, light or dark red, dull, unattractive; apex somewhat pointed, inclined to green tips; flesh light colored toward the center, medium in juiciness, firm, mild subacid; fair in quality.

Plant-characters good except in productiveness. The tall, light green foliage is characteristic of the variety. A very early sort, fruit of which is inferior in size, coarse and unattractive in appearance and of second rate quality.

July.—(M. Crawford Company, Cuyahoga Falls, O.) A seedling of Warfield crossed with Ionia originating with H. J. Schild, Ionia, Mich., in 1902, and introduced by him in 1907.

Plants of medium number and size, healthy, productive. Leaves smallish, thick, light green, nearly glabrous; leaf-stems medium in length, slender, greenish. Flowers and the first fruits which set showing distinctly above the foliage, imperfect, blooming late, $1\frac{1}{4}$ inches across; petals oval, usually 5 in number. Calyx large, flattened, leafy. Seeds raised. Fruit maturing in mid-season; above medium in size, conic, light red; apex pointed; flesh well colored, very juicy, medium firm, tart; fair in quality.

Plants intermediate in habit of growth but productive. The flowers and first fruits set show distinctly above the foliage; a very light colored tart berry, easily bruised, dropping rapidly in size and inferior in quality.

Kevitt Wonder.—(T. C. Kevitt, Athenia, N. J.) A seedling of Bismarck crossed with Parker Earle originating in 1906 with Mr. Kevitt and introduced by him in 1908.

Plants few, smallish, healthy, productive. Leaves of medium size, thick, dark green, slightly rugose; leaf-stems short, thick. Flowers perfect, intermediate in season of bloom, $1\frac{3}{16}$ inches across; petals roundish, 5 or 6 in number; stamens numerous, medium in length. Calyx rather small. Seeds

slightly raised. Fruit maturing in mid-season; above medium in size, characteristically elongated averaging oblong-conic, slightly necked, medium scarlet, glossy and attractive; apex pointed; flesh not very juicy, medium in firmness, mild, not high-flavored; inferior in quality.

Plants productive, make few runners and although healthy lack somewhat in vigor. Fruit characteristically elongated, well colored, lacking somewhat in juiciness, surpassed in quality by other varieties.

Kitty Rice.—(M. Crawford Company, Cuyahoga Falls, O.) Originated by John F. Beaver, Dayton, O., about 1890. The M. Crawford Company gave it as a premium in 1896 under the name Downing Bride and again as a premium in 1899. The name was changed to Kitty Rice in 1903.

Plants of medium number, above medium in size, healthy, productive. Leaves of average size and thickness, medium green, not pubescent; leaf-stems rather long, of average thickness. Flowers imperfect, averaging $1\frac{1}{8}$ inches across; petals obovate tapering at the base, 6 or 7 in number; pistil-center small. Calyx large, flattened, reflexed, leafy. Seeds medium in size and number, slightly raised. Fruit maturing in mid-season; above medium in size, conic or inclined to wedge-shape, medium scarlet, glossy and attractive; apex medium pointed; flesh light colored toward the center, very juicy, of medium firmness, high-flavored, tart unless fully ripe, when it becomes sweet; very good to best.

Habits of growth desirable. A mild mid-season variety unusually high in quality, dropping in size as the season advances, well shaped and colored; the large, leafy, pale calyx detracts slightly from appearance. Somewhat tart unless fully mature. Worthy of testing on account of high quality.

Labell.—(E. H. Ekey, Steubenville, O.) A seedling of unknown parentage originating about 1899 with Mr. Ekey. Not yet introduced.

Plants few, of average size and vigor, healthy, productive. Leaves medium in size and thickness, light green, not pubescent; leaf-stems below medium in length, of average thickness. Flowers imperfect, intermediate in season of bloom, $1\frac{1}{8}$ inches across; petals roundish-oval, 5 to 7 in number. Calyx of medium size, raised. Seeds sunken. Fruit maturing late; large, long wedge-shaped or conic, necked, variable in color averaging dark red, not glossy; apex pointed or obtuse; flesh well colored, very juicy, firm, tart; fair in quality.

The productive plants develop but few runners and are intermediate in habit of growth. Flowers imperfect, maturing late. Fruit of good size only in the first pickings. Somewhat coarse in appearance, variable in color and, although very juicy, inferior in flavor and quality.

Manhattan.—(Kenridge Fruit Farm, Cliffwood, N. J.) A seedling of unknown parentage found in the farm of J. E. Kuhns, Cliffwood, N. J., in 1907 and introduced by him the spring of 1910.

Plants characteristically few in number, small, healthy, moderately productive. Leaves of average size, thick, dark green; leaf-stems short, thick. Flowers perfect, intermediate in season of bloom, $1\frac{1}{4}$ inches across; petals roundish, often 9 in number; stamens numerous, medium in length. Calyx small,

flattened. Seeds very conspicuous, raised, often hairy. Fruit maturing rather late; above medium to below in size, conic or wedge, light scarlet, dull; apex pointed or obtuse; flesh juicy, firm, tart, not pleasant; inferior in quality.

An unusually poor plant-maker and inferior in habits of growth. Not adapted to the Station soil as the fruit is surpassed by many varieties in size, color, flavor and quality.

Mascot.—(W. F. Allen, Salisbury, Md.) A variety said to have originated in Virginia.

Plants intermediate in number and size, healthy, productive. Leaves of average size and thickness, intermediate in color; leaf-stems medium in length, slender. Flowers perfect, blooming very early, $1\frac{1}{4}$ inches across; petals roundish-oval, 5 or 6 in number; stamens numerous, long. Calyx medium to large, flattened. Seeds large, prominent, numerous, raised. Fruit maturing very early; above medium in size, elongated-conic, light scarlet, unusually glossy and attractive; apex pointed or indented; flesh well colored, very juicy, medium in firmness, subacid or tart, pleasant flavored; of good quality.

Plant-habits good except in the very early opening of the flowers which are liable to be caught by late spring frosts. One of the first to ripen. Fruit of fairly good size in the earlier pickings becoming small later; quite productive for an early kind. Often characteristically glossy and with conspicuous, raised seeds. Not as sweet as some varieties, yet agreeable; worthy of testing for an early variety, although not as large as might be desired.

Matthew Crawford.—(M. Crawford Company, Cuyahoga Falls, O.) Originated by J. R. Peck, Breckkenridge, Mo.; given as a premium in 1908 by the Crawford Company.

Plants numerous, characterized by an extremely dwarfish habit of growth, healthy, moderately productive. Leaves small, of average thickness, light green; leaf-stems very short, medium in thickness. Flowers perfect, blooming very late, $1\frac{3}{16}$ inches to $1\frac{1}{8}$ inches across; petals roundish to obovate, 6 or 8 in number; stamens numerous, rather long. Calyx of medium size, flattened. Seeds small, inconspicuous, sunken. Fruit maturing very late; large, symmetrical, conic, light scarlet, glossy and attractive; apex medium-pointed; flesh light colored toward the center, juicy, medium in firmness, mild subacid, not highly flavored; fair to good.

Plants are produced in goodly numbers, extremely dwarfish in habit of growth, lacking somewhat in productiveness. Blooms and ripens very late. Fruit makes a good showing in the first pickings but too mild in flavor and too variable later both in size and color.

Monroe.—(J. A. Morgan, Scottsville, N. Y.) A seedling of Sample which grew near plants of Rough Rider and Parker Earle, originating in 1905 with Mr. Morgan who intends to introduce it the spring of 1911.

Plants numerous, of medium size and vigor, somewhat susceptible to attacks of leaf-blight, medium in productiveness. Leaves above average size, thick, dark green; leaf-stems intermediate in length and thickness, greenish. Flowers perfect, blooming rather early, $1\frac{1}{8}$ inches across; petals roundish, 5 or 6 in number; stamens numerous, rather long. Calyx large, flattened,

leafy. Seeds sunken. Fruit maturing early; large, roundish to roundish-conic, variable in color averaging light red, rather attractive; flesh juicy, medium in firmness, sweet or subacid, mild; good in quality.

Plants somewhat subject to disease, fairly good in habits of growth. Fruit retains size well in later pickings and although somewhat coarse in general appearance appears worthy of test on account of earliness and good size especially in the first pickings. Later some berries color unevenly.

Myer.—(Slaymaker & Son, Dover, Dela.) A seedling of unknown parentage found by Myer & Son, Bridgeville, Dela., in 1906 in a bed of about 25 varieties. Introduced by Myer & Son in 1908.

Plants intermediate in number and size, healthy, very productive. Leaves medium in size, thin; leaf-stems of average length and thickness. Flowers imperfect, blooming fairly early, 1 inch to 1½ inches across; petals broadly ovate, 6 to 9 in number. Calyx large, leafy, depressed. Seeds sunken. Fruit maturing in mid-season; above medium in size, regular, conic, medium scarlet, glossy and attractive, inclined to color unevenly; flesh light colored toward the center, characteristically not juicy, medium in firmness, mild, sweet; good in quality for a mild berry.

Plant-habits good. Fruit rather dry, not a very good shipper; good quality for a mild berry.

Nonsuch.—(J. S. Berry, Logansport, Ind.) Found growing wild in a fence corner by Peter A. Berry, Logansport, Ind., in 1895, and sent to this Station for testing by his brother. Not yet introduced. Thought to be a seedling of Sharpless as that variety was growing near the place of origin. Mr. Berry states that it is a valuable late variety in his neighborhood, known locally as "Nonsuch" and that it should always be grown in the narrow row or in hills and that it is more productive the second and third year than the first season of fruiting.

Plants very numerous and vigorous, large, slightly subject to attacks of mildew and leaf-blight, very productive. Leaves of medium size, light green; leaf-stems long, slender. Flowers perfect, season of bloom late, 1¼ inches across; petals 8 to 10 in number; stamens numerous, rather long. Calyx of average size, flattened or slightly depressed, reflexed. Seeds medium in size, prominent, variable in position. Fruit maturing very late; variable in size averaging above medium, irregular in shape, oblong, wedge or sometimes conic, light red, rather unattractive, coloring unevenly; apex obtuse, often green-tipped; flesh light colored toward the center, juicy, firm, subacid, slightly aromatic; of good quality.

At blooming time the blossoms are characteristic, appearing in masses above the foliage; although the plant-growth is good and the fruit retains its size well, it is too light in color, and too variable in shape; subject to green tips; unpromising.

Orem.—(M. Crawford Company, Cuyahoga Falls, O.) Introduced by J. H. Arndt, Arlington, Md., in 1908.

Plants numerous, of average size and vigor, healthy, productive. Leaves intermediate in size, thick, dark green; leaf-stems of average length and

thickness. Flowers perfect, intermediate in season of bloom. $1\frac{5}{16}$ inches across; petals roundish-oval, 5 to 7 in number; stamens numerous, rather long. Calyx large, flattened, leafy. Seeds variable in position. Fruit maturing late; very large; roundish-conic or wedge, medium scarlet, attractive; apex very obtuse, often green-tipped and sometimes forming a nubbin; flesh well colored, medium juicy, firm, tart; good in quality.

Plant-habits good; fruit unusually large, retains size well but inclined to green tips and with a somewhat tough core. Rather promising in the first pickings but somewhat disappointing later. Requires further testing to determine its value.

Orphan.—(J. A. Morgan, Scottsville, N. Y.) Found growing alone in a clover sod in the spring of 1904 by Mr. Morgan and named by him.

Plants intermediate in number and size, healthy, productive. Leaves large, thick, medium green, rugose; leaf-stems long, thick. Flowers imperfect, blooming late, $1\frac{1}{8}$ inches across; petals roundish, 5 to 7 in number. Calyx large, flattened, leafy. Seeds sunken. Fruit maturing late; large, wedge-shape or conic, medium to light red, dull, rather unattractive, colors unevenly; apex, obtuse; flesh well colored, juicy, medium in firmness, subacid, not high-flavored, poor in quality.

A late blooming imperfect-flowering variety of good plant-habits but the fruit, although rather large throughout the season, is unattractive in color and inferior in quality.

Outlander.—(A. T. Goldsborough, Wesley Heights, Washington, D. C.) A seedling of Royal Straight Flush crossed with Fujiyama originating with Mr. Goldsborough and introduced by him in 1906.

Not enough plants for a good test. Appears to be a late blooming and very late ripening variety, of good size, wedge to roundish-conic, attractive medium scarlet; flesh rather firm, light colored at the center, sweet; of very good quality. Requires further test to determine its value.

Parcell Early.—(G. A. Parcell, Pine City, N. Y.) Mr. Parcell describes its origin as follows: "In 1902 I fruited on new land, Haverland fertilized on one side by Excelsior and on the other by Lovett. These were plowed under and in 1903 this variety was saved from among other self-sown seedlings. It is probably a seedling of Haverland and Excelsior. Will be introduced by W. F. Allen, Salisbury, Md., in 1912."

Plants intermediate in number and vigor, healthy, rather productive. Leaves rather small, medium thick, moderately light green; leaf-stems short, slender. Flowers perfect, opening very early, $1\frac{1}{8}$ inches across; petals roundish, 5 or 6 in number; stamens medium in number, short. Calyx small, raised. Seeds of medium size, variable in position. Fruit maturing very early; above medium in size, conic, somewhat necked, attractive light scarlet; apex pointed or obtuse; flesh well colored, juicy rather firm, tart, sprightly; of good quality.

The first variety to ripen in 1910. Somewhat of the type of Senator Dunlap but blooming and ripening earlier. The writer observed this variety fruiting in 1910 on the grounds of Mr. Parcell where it is unusually promising and



PLATE XVI.—PARCELL EARLY.

where its habits of growth are much superior to those on the Station soil which is a cold, heavy, clay loam; worthy of testing on warmer and lighter soils which contain an abundance of nitrogenous plant food.

Paul Jones.—(R. W. Johnson, Northboro, Mass., and C. S. Pratt, Reading, Mass.) A seedling of Haverland pollinated by Brandywine originating with Wm. H. Johnson about 1898 and introduced by his son, Richard W. Johnson, in 1908.

Plants numerous, above medium in size and vigor, healthy, very productive. Leaves small, thin, medium green, pubescent; leaf-stems long, very slender. Flowers imperfect, nearly $1\frac{1}{2}$ inches across; petals ovate, 7 or 8 in number. Calyx large, flattened. Seeds large, numerous, sunken, hairy. Fruit maturing in early mid-season, above medium in size, unattractive in shape, long-conic varying to wedge, dull, unattractive light scarlet, colors unevenly; apex often strongly pointed and green-tipped; flesh light colored toward the center, medium in juiciness, intermediate in firmness, subacid, inferior in flavor; poor in quality.

Plants unusually productive, of good habits of growth. Fruit characteristically long-conic, a good shipper, retains size fairly well throughout the season, inferior in flavor, low in quality.

Red Bird.—(M. Crawford Company, Cuyahoga Falls, O.) A seedling of Murray crossed with Hoffman originating in 1902 with S. Wherry & Sons, Durant, Miss., and introduced by them in 1907.

Plants intermediate in number and size, healthy, unproductive. Leaves of medium size and thickness, nearly smooth; leaf-stems of average length, slender; flower-stems long, branched. Flowers imperfect, season of bloom medium early, $\frac{7}{8}$ inch across; petals oval, 5 in number. Calyx rather small, flattened or slightly raised. Seeds numerous, much sunken. Fruit maturing early; large to above medium, roundish-conic or wedge, sometimes necked, attractive, glossy, light scarlet; apex obtuse; flesh well colored, not very juicy, tender, sprightly subacid or tart, high-flavored; good to very good.

Plants intermediate in habit of growth, healthy, unproductive. Flower-stems long, slender, much branched; a high quality early berry, too tart for most purposes. Surpassed by other varieties.

Rockhill No. 6. (Harlow Rockhill, Conrad, Ia.) A seedling of Senator Dunlap pollinated with Pan-American, originating in 1906 with Mr. Rockhill.

Plants characteristically few in number, below medium in size and vigor, healthy, productive. Leaves of medium size and thickness, dark green; leaf-stems short, slender. Flowers perfect, blooming rather early. Calyx small, depressed. Seeds sunken. Fruit ripening in mid-season; above medium to medium in size, conic or wedge, glossy, attractive medium scarlet, colors unevenly; apex usually obtuse; flesh well colored, not very juicy, firm, mild, not high-flavored, subacid; fair in quality.

Plants markedly few in number, inferior in vigor but productive. Fruit averages too small, variable in color, ships well, surpassed by other varieties in quality.

Rockhill No. 7. (Harlow Rockhill, Conrad, Ia.) A seedling of Senator Dunlap pollinated with Pan-American, originated in 1906 by Mr. Rockhill.

Plants very few, intermediate in size and vigor, healthy, unproductive. Leaves of average size and thickness, dark green, rugose; leaf-stems of medium length, slender. Flowers perfect, blooming rather early. Calyx of average size, flattened or raised. Seeds raised. Fruit maturing in mid-season; above medium to below in size, conic, sometimes slightly necked, rather attractive dark scarlet; apex pointed; flesh well colored, juicy, firm, aromatic, high-flavored, sweet; very good.

Plants moderately vigorous, healthy, unproductive, developing but few runners. A dark berry of high quality lacking in size.

Rockhill No. 9. (Harlow Rockhill, Conrad, Ia.) A seedling of Senator Dunlap pollinated with Pan-American originating with Mr. Rockhill in 1906.

Plants medium in number, large, vigorous, healthy, unproductive. Leaves of medium size, thick, the margins broadly serrate tipped with red, dark green, rugose; leaf-stems long, slender. Flowers perfect, intermediate in season of bloom. Calyx medium in size, flattened. Seeds large, conspicuous, raised. Fruit maturing early; above medium to medium in size, conic, glossy, attractive medium scarlet; apex somewhat pointed; flesh well colored, juicy, firm, mild subacid; fair to good.

Plant-characters desirable except in productiveness. An early ripening variety attractive in color but deficient in size and surpassed in quality by other varieties; has a marked tendency to produce fruit in the fall.

Rockhill No. 10. (Harlow Rockhill, Conrad, Ia.) A seedling of Laxton Commander crossed with Pan-American originating in 1906 with Mr. Rockhill.

Plants rather few, medium in size and vigor, healthy, very productive. Leaves of average size and thickness, medium green, slightly rugose; leaf-stems medium in length and thickness. Flowers perfect, blooming very early. Calyx large, leafy. Seeds sunken. Fruit maturing in mid-season; variable in size, averaging above to below medium, irregular conic, the surface deeply furrowed, dull, unattractive dark scarlet; apex variable in shape; flesh light colored toward the center, not very juicy, mild subacid; fair in quality.

Plants from the few runners are very productive and of fairly good vigor. The chief faults appear in the fruit which runs too small, is unattractive in color and shape and low in flavor and quality.

Rockhill No. 11. (Harlow Rockhill, Conrad, Ia.) A seedling of Brandywine crossed with Pan-American originating in 1906 with Mr. Rockhill.

Plants numerous, above medium in size and vigor, somewhat susceptible to attacks of leaf-blight, moderately productive. Leaves above medium in size, thick, medium green; leaf-stems of average length and thickness. Flowers perfect, intermediate in season of bloom. Calyx of average size, flattened. Seeds large, conspicuous, numerous, raised. Fruit maturing in mid-season; above medium in size, roundish-conic, glossy, attractive light scarlet; apex obtuse; flesh light colored toward the center, juicy, firm, mild, aromatic, sweet; very good in quality.

A good plant-maker and desirable in other plant-habits but somewhat susceptible to attacks of leaf-blight. Fruit of good color and shape; retains size fairly well although not large, very good for a mild, sweet berry. One of the best of Mr. Rockhill's seedlings described in this bulletin. Lack of size appears to be its greatest fault.

Rockhill No. 12. (Harlow Rockhill, Conrad, Ia.) A seedling of Brandywine crossed with Pan-American originating in 1906 with Mr. Rockhill.

Plants few, medium in size and vigor, healthy, productive. Leaves large, thick, dark green, rugose; leaf-stems medium in length, rather thick. Flowers perfect, blooming medium early. Calyx of average size, flattened or slightly raised. Seeds conspicuous, raised. Fruit maturing in mid-season; above medium to medium in size, blunt wedge-shape to roundish-conic, sometimes slightly necked, rather dull, dark scarlet; flesh well colored, juicy, medium firm, mild, pleasant flavored, sweet; very good in quality.

A poor plant-maker but productive and free from disease. Fruit of very good-quality, variable in color and principally deficient in size.

Salisbury.—(E. W. Townsend & Company, Salisbury, Md.) A chance seedling introduced by Townsend & Company in 1906.

Plants few, intermediate in size and vigor, healthy, moderately productive. Leaves of average size and thickness, medium green, slightly rugose; leaf-stems medium in length, slender. Flowers imperfect, intermediate in season of bloom, 1 inch across; petals small, roundish, 5 in number. Calyx small, flattened or depressed. Seeds variable in position. Fruit maturing late; large to medium, wedge-shape or conic, dull, unattractive light scarlet; flesh very juicy, tender, subacid; inferior in quality.

A poor plant-maker, intermediate in vigor and productiveness. Fruit late, drops rapidly in size, inferior in color, firmness and flavor and somewhat subject to sun-scald; color a lighter scarlet than most varieties.

Sherman.—(Samuel Cooper, Delevan, N. Y.) A seedling of Pan-American originated by Mr. Cooper in 1903. Not yet introduced.

Plants numerous, above medium in size and vigor, healthy, productive. Leaves large, of average thickness, characteristically dark green, rugose; leaf-stems above medium in length, thick. Flowers imperfect, intermediate in season of bloom, 1 inch across; petals roundish-oblato, 6 or 7 in number. Calyx large, flattened or depressed, leafy. Seeds sunken. Fruit maturing in mid-season; large, conical or roundish-conic, glossy, attractive medium scarlet, coloring unevenly; apex pointed or obtuse; flesh well colored, very juicy, firm, tart; good for an acid berry.

Plant-characters unusually good. Foliage markedly dark green. Fruit of good size which is well retained throughout the season, somewhat variable in shape, very juicy, of good quality for a tart berry. Worthy of more extended trial.

Silver Coin.—(J. T. Lovett, Little Silver, N. J.) A seedling of unknown parentage originating with Wellington W. Kennedy, Red Bank, N. J., in 1902, and introduced in the fall of 1908 and spring of 1909 by J. T. Lovett, Little Silver, N. J.

Plants medium in number, size and vigor, healthy, moderately productive. Leaves large, of average thickness, dark green, rugose; leaf-stems of medium length and thickness. Flowers perfect, intermediate in season of bloom, $1\frac{1}{2}$ inches across; petals roundish, 6 or 7 in number; stamens numerous, rather long. Calyx of average size, flattened or depressed. Seeds small, raised. Fruit ripening late; above medium in size, roundish-conic, dull, light scarlet; apex obtuse; flesh well colored, very juicy, tender, not pleasant in flavor, subacid; fair in quality.

Plant-characters fairly good in all respects. Fruit inferior in color, firmness and flavor and inclined to sun-scald. Surpassed by other varieties.

Stall No. 1. (F. A. Stall, Lockport, N. Y.) A seedling of Sample originating with Mr. Stall in 1906. Not yet introduced.

Plants intermediate in number, large, vigorous, healthy, productive. Leaves of average thickness, medium green; leaf-stems of medium length and thickness. Flowers large, perfect, nearly $1\frac{3}{8}$ inches across; petals broad-ovate, 6 or 7 in number; stamens numerous, rather long. Calyx medium in size, depressed. Seeds numerous, sunken. Fruit maturing in mid-season; unusually good in size, conic, glossy, attractive dark scarlet; flesh light colored toward the center, juicy, moderately firm, aromatic, high-flavored, sweet; very good to best for a mild berry.

A large-flowered, productive variety with desirable habits of plant-growth. Fruit unusually promising in size, color and quality. Worthy of testing for a mild, mid-season variety of high quality.

Stevens Great American.—(S. D. Stevens & Son, Bridgeton, N. J.)

Plants intermediate in number, size and vigor, healthy, moderately productive. Leaves large, of average thickness, slightly darker green than Stevens Late Champion, rugose; leaf-stems long, medium thick. Flowers perfect, intermediate in season of bloom, $1\frac{1}{2}$ inches across; petals roundish-oval, yellowish at the base, usually 7 in number; stamens numerous, medium in length. Calyx large, flattened or slightly raised. Seeds sunken. Fruit maturing in mid-season; large, conic, sometimes slightly necked, glossy, attractive medium scarlet; apex pointed or obtuse; flesh well colored, very juicy, firm, tart, sprightly; good in quality.

A perfect-flowering variety ripening in mid-season several days earlier than Stevens Late Champion. Plant-characters much like those of that variety but slightly less productive. A tart berry of good quality; more promising in the earlier pickings than later.

Superior.—(E. W. Townsend & Company, Salisbury, Md.) Said to have been introduced from Delaware.

Plants numerous, large, vigorous, healthy, productive. Leaves above average size and thickness, medium green; leaf-stems long, slender. Flowers perfect or semi-perfect, blooming very early, $\frac{7}{8}$ -inch across; petals small, roundish, usually 5 in number; stamens medium in number. Calyx of average size, flattened, leafy. Seeds conspicuous, raised. Fruit maturing in mid-season; large to medium, conic or wedge, glossy, attractive bright scarlet; apex variable in shape; flesh well colored, juicy, firm, aromatic, high-flavored, subacid or sweet; very good in quality.

Habits of growth unusually good. A very early blooming variety the flowers of which may be injured some years by late frosts. Of good size at first, dropping to rather small later in the season; berries bright scarlet, of very good quality, somewhat seedy in appearance. Worthy of testing further.

Swedenberg.—(David Knight & Son, Sawyer, Mich.) Parentage unknown but thought to be a chance seedling of Beder Wood found in the hills near Sawyer, Mich., about 1907, by Chas. Schwichtenberg (pronounced Swedenberg). Distributed as a premium in 1910 by Knight & Son.

Plants intermediate in number, size and vigor, somewhat subject to attacks of leaf-blight, very productive. Leaves medium in size and thickness, dark green; leaf-stems medium in length, slender. Flowers perfect, blooming medium early, $\frac{3}{4}$ -inch across; petals small, roundish-oval, 5 or 6 in number; stamens numerous, rather long. Calyx of medium size, flattened. Seeds raised, slightly hairy. Fruit maturing early; large, roundish-conic, broad at the base, light scarlet; apex obtuse; flesh light colored toward the center, moderately juicy, rather tender, not high-flavored, subacid; poor to fair.

A very productive variety with fairly good plant-habits but somewhat subject to injury from attacks of leaf-blight. Fruit characteristically light red and broad at the base of the roundish-conic berries. Flesh lacks good color, is a poor shipper and is inferior in flavor and quality.

Taft.—(A. T. Goldsborough, Wesley Heights, Washington, D. C.) A seedling of Goldsborough crossed with Royal Straight Flush, originating with Mr. Goldsborough and introduced by him in 1906. This variety must not be confused with the variety named "W. H. Taft" nor with the variety introduced under the name "Taft" in 1909.

Plants intermediate in number, vigorous, healthy, productive. Leaves large, medium green; leaf-stems of average length, rather slender. Flowers imperfect, intermediate in season of bloom, nearly $1\frac{3}{16}$ inches across; petals roundish-ovate, 5 to 8 in number. Calyx inclined to detach readily from the fruit. Seeds prominent. Fruit maturing in early mid-season; large, retains size well throughout the season, blunt wedge to roundish-conic, with somewhat roughish surface, attractive dark scarlet; apex pointed; flesh well colored, aromatic; high-flavored, juicy, sweet; good to very good in quality.

Plant habits good; fruit desirable in size and color; in later pickings slightly coarse in appearance.

Wooster.—(J. H. Hale, South Glastonbury, Conn.) Thought to be a seedling of Sample crossed with Clyde; originated on the farm of E. W. Wooster, South Hancock, Me., in 1904, and introduced by Mr. Wooster in 1908.

Plants medium in number, above medium in size and vigor, healthy, unproductive. Leaves large, thick, dark green, rugose; leaf-stems above medium in length, of average thickness. Flowers imperfect, intermediate in season of bloom, $\frac{3}{4}$ -inch across; petals small, tinged with yellowish-green, roundish, usually 5 in number. Calyx of average size, flattened. Seeds sunken. Fruit maturing early; large, roundish-conic, rather attractive, medium to light scarlet; apex obtuse; flesh rather light colored, medium in juiciness, of average firmness, mild, pleasant, sweet; fair in quality.

An imperfect-flowering variety, plants of which possess fairly good qualities. Fruit matures early, retains size well throughout the season but the color of both surface and flesh is too unattractive; quality inferior.

STATION SEEDLINGS.

In the spring of 1908 three seedlings, the most promising of 544 plants, were sent out for testing from this Station under the names Prolific, Magnus and Quality. A large number of reports have been received concerning them, and the varieties have also been under observation at the Station. Quality has not continued to make a good record and has been discarded. The reports on Magnus indicate that this variety may have more value for home use than for commercial purposes as was predicted in Bulletin No. 298 issued at the time of its introduction. Prolific has made a good record in most places and many growers are planning to test this variety on a larger scale for commercial purposes. The Station has no more plants of these varieties for distribution.

CULTURE OF STRAWBERRIES.

Location and selection of soil.—Strawberries do well under widely different soils and climate. A majority of varieties reach a better development, however, on the lighter, sandy loams than on the colder and more compact clay soils. Suitable varieties may be found for almost any location. The amount of profit is often measured by a few days difference in the ripening season where the earliest or the latest varieties are demanded. A quick soil, a sandy loam well stocked with plant food, and a southern slope favor early crops. The heavier clay loams and a northern exposure are preferable for the late crops. All soils for strawberries as well as for other fruits should have thorough natural or artificial drainage. Soils retentive of moisture are usually preferable to those that dry out too quickly, and if there is much danger from late spring frosts an elevation may be safer than bottom lands. The heavier soils also tend to produce berries that ship long distances better than when grown on the lighter soils.

Preparation of soil.—Weedy soils increase the expense of growing the crop and decrease the yield. Hoed crops such as potatoes, beans, cabbage or corn preceding strawberries will leave the land much freer from weeds; and the soil will be in better tilth if manure be applied heavily for the preceding crop. For most soils deep plowing will cause the plants to root more deeply and will conserve moisture. It may be done in the fall or spring, preferably in the fall, plowing again in the spring, following with thorough cultivation to make the soil fine and mellow. Too little attention is given to thoroughly pulverizing the soil before setting the plants. A clover sod plowed under is of great value but a grass sod should be avoided as it usually harbors insects destructive to the roots of the strawberry plants.

Manure and fertilizer.—There is usually but little danger of making the soil too rich for strawberries. Available plant food should be present to meet the requirements of the plants, and the soil should be liberally fertilized to secure maximum yields. Well rotted manure thoroughly worked into the soil is one of the best fertilizers. Coarse manure will give good results if turned under early enough to become well decomposed before setting the plants, as will also cover-crops or clover sod as previously indicated. These foods are largely valuable because of their humus, which improves the physical condition of the soil and also its ability to withstand drought. The presence of humus is necessary to secure best results and its absence often accounts for low yields, especially in dry seasons. Weed seeds from the compost heap may at times cause trouble.

Additional applications of plant food in the form of commercial fertilizers may be necessary. The kind and amount to use, the time and manner of application depend on conditions. These differ as to methods of growing the crop, character of soil, of season, and of the variety of strawberry grown. Soils may lack nitrogen, potash or phosphoric acid. Applications of nitrogen in the form of nitrate of soda using from two hundred to three hundred pounds per acre or dried blood at the rate of from three hundred

to six hundred pounds per acre will stimulate growth. Too much nitrogen sometimes causes a rank growth at the expense of the fruit. Potash may be supplied by using wood ashes, two thousand pounds per acre, or muriate of potash, using from two to three hundred pounds per acre. A lack of phosphoric acid may be supplied in the form of acid phosphate, six hundred to seven hundred pounds per acre. Other fertilizers might be named. If the soil is well supplied with any form of plant food it is useless to make additional applications of that kind. The aim should be to find the actual need of each soil. To this end it is desirable

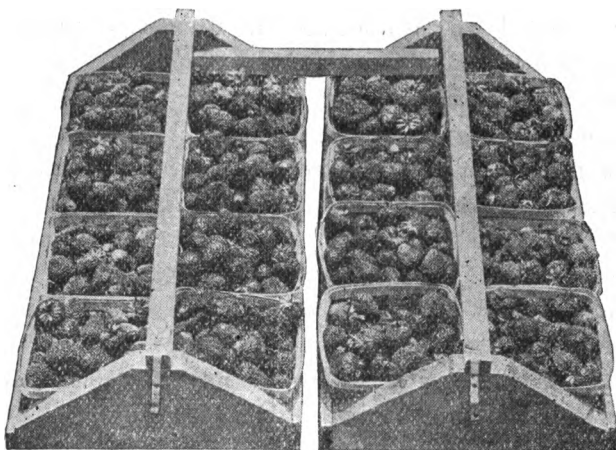


FIG. 2.—TYPE OF DESIRABLE COMMERCIAL VARIETY.

to make tests of different fertilizers leaving check rows for comparison. It must be understood that these fertilizers will not take the place of humus, nor of a good physical condition of the soil.

No rule can be given regarding the proper application of fertilizers. Soils differ in all their properties, and the condition should govern the application. Each grower must use his own judgment based on observation or experience to determine what to apply. For new beds the fertilizer may be applied broadcast in the spring before setting the plants, harrowing it in, or scat-

tered along the plant rows after setting, cultivating until well mixed with the soil. Sometimes applications of nitrate of soda may be given the fruiting beds before blossoming time, broadcasting directly over the plant rows. For beds held over for a second crop apply the fertilizer or rotted stable manure along the rows after they have been cleaned out following fruitage.

Selection of varieties.—Under different environments, and under unlike surroundings, the same variety may be most profitable or become worthless. It may succeed admirably in one place and yet be a failure elsewhere. In no two localities are the same varieties equally valuable. Adaptation should be determined by a test of a few plants before an extensive use in the commercial plantation. In this way the few kinds best suited to a location may be found. The character of the market may affect the selection; it may require early or late kinds; or firm varieties capable of being shipped long distances; sometimes the demands of canneries must be considered. It is safe to say that no kind has all of the qualities equally developed that go to make perfection. The newer, most promising kinds should be tested in a small way and their merits determined before making extensive plantings. This is especially true of the fall-bearing varieties which are being sold at the present time.

Sex of plants.—The sex of the variety should be known. Some

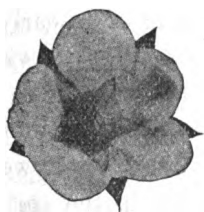


FIG. 3.—IMPERFECT, OR PISTILLATE FLOWER.

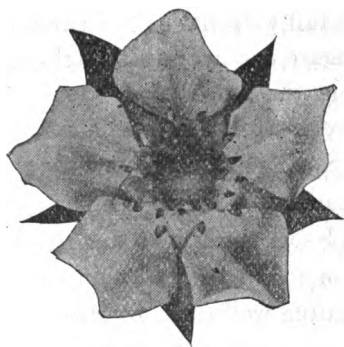


FIG. 4.—PERFECT FLOWER.

varieties have perfect blossoms, also called hermaphrodite, staminate, bi-sexual or male. Such kinds bear flowers containing both stamens and pistils. All such varieties bear fruit when planted alone. Other varieties have imperfect blossoms, also called pistillate or female. These varieties will not bear fruit if grown by themselves, with none of the other kind in the neighborhood. To insure fertilization of the blossoms they should be set in rows of from one to three alternating with rows of the perfect-flowering varieties, which bloom at the same time.

Bees and other insects in visiting the perfect flowers, become more or less covered with the sticky pollen which adheres to them and is carried to other blossoms and left on the pistils which are thus fertilized. Incomplete fertilization is usually indicated by the presence of nubbins, berries with hard, greenish, undeveloped apex. Too much rain, frost or cool temperatures, or the absence of pollen-distributing insects at blooming time may greatly decrease the setting of fruit.

Time of planting.—Periods of drought usually occur during the fall months and when plants are set under such conditions, there may be considerable loss. Fall-set plants require winter protection and the usual cultural care during the ensuing summer followed by a second winter's protection before a full crop of fruit may be secured. Plants obtained by rooting the first runners in small pots plunged in the soil along the row are sometimes set in the fall with the ball of earth adhering to the roots but this method is more expensive although it permits the taking of an early crop from the land before setting the strawberries. But few runners develop from fall set plants before growth ceases.

Spring-setting is usually preferable as it shortens the time from planting to fruitage and at the same time secures better weather and soil conditions and it may be begun early in the spring as soon as the soil and plants are in good condition for this work, extending well through May. There is also opportunity if necessary to reduce the number of weeds greatly by thorough cultivation after growth begins and before setting the plants.

Selection of plants.—The best stock obtainable should be used. Plants from old beds are usually weakened in vitality and may be infested by insects or diseases. Vigorous, healthy plants should be selected from well-cared-for beds which have not yet fruited. Careful selection and continued propagation should result after a few years in an improved strain with fixedness of character. If the so-called “pedigree” plants are superior to others it is because of the character of the parentage, the family traits having become permanent through long years of careful and intelligent breeding; not all of the “pedigree” plants on the market have this fixedness of character.

Preparation of plants.—After the plants have been dug, they are trimmed for setting by removing all dead leaves and runners and all except one or two of the green leaves. The roots are usually shortened back about one-third their length. They should never be allowed to dry out.

Distance of planting.—At fruiting time strawberry plants are usually badly crowded. Sufficient moisture is essential to good size and yield, and is not available under crowded conditions. The distance apart of rows and plants should vary depending on richness of soil, ability of the variety to make runners, methods of culture, and season of planting. Plants may be set and treated to make wide or narrow matted rows, or they may be kept in hills. The narrow matted row is generally preferable for commercial purposes, the rows from three to four feet apart, and the plants usually from eighteen to thirty inches apart depending on the character of the variety as a plant-maker. The chief difference between the narrow and wide matted row is that the former is about one foot in width while the latter is about double that distance. The “hill” system consists in both rows and plants being slightly closer together and in growing each plant by itself in a hill, removing all runners that develop. Fruit from such plants is usually larger and makes a better appearance but the labor item is increased. The matted row requires less labor and the yield is usually greater.

Setting the plants.—Previous to setting, the land should be marked both ways; or the ground may be marked crossways to the direction of the rows, setting along a line stretched from end to end of the row. The roots of the plants should be kept moist, and a pail containing a little water or damp moss will be found convenient. A trowel, flat dibber, or narrow well-scoured spade may be used to open the soil for the plants, the latter being most convenient for large plantings. Insert the spade and by pressing forward make a wedge-shaped opening. The roots, spread fan-shape, may be inserted in this space which should then be closed and the soil pressed firmly against the roots. The two most important points to observe in planting are to place the roots at the right depth and to press the soil firmly about them. The crown of the plant should not be so deep as to be covered with earth nor should it be set so high as to expose the roots. It should be level with the surface. If too deep the crown is liable to rot and if too shallow the roots dry out.

Treatment the first summer.—Cultivation should begin as soon as the plants are set and be continued throughout the summer and fall when necessary to keep the ground free from weeds which rob the soil of both moisture and plant food, to retain a mellow soil condition, to assist in breaking down plant food, to conserve moisture, or to maintain a steady, normal growth. If the distance apart of plants is sufficient the cultivation should be both ways until the runners begin to make plants. The tillage or hoeing should never be deep enough to disturb the shallow root system, especially in hot, dry weather.

Fruitage lessens plant growth. Flower-clusters should therefore be removed as soon as they appear, to secure stronger plants from which the runners will develop later. The first runners that start should not be cut off but be encouraged to root as soon as possible by "bedding in" or placing in a position where they will root readily and will not be disturbed by the cultivator. This gives a long season for the young plants to develop in size and

maturity. They, however, should not become crowded and it may be necessary to thin out some of the later ones before the season of growth ends.

In the fall, some growers stop cultivation early, sowing among the plants oats or barley which die down after the first frosts. This gives a slight protection as a cover-crop or mulch over winter and helps somewhat to keep the ground from baking in the spring and to keep the berries clean. It is doubtful, however, if this practice although a cheap one, is as desirable as the method suggested under "winter treatment" owing to the large amount of water removed by the oats or barley which in a dry fall must result in a decreased vigor of the strawberry plants, and also because of insufficient winter protection.

Winter treatment.—Repeated freezing and thawing weaken the plants and tend to reduce the yield. Winter protection of some form should be given. The most desirable covering is one which is free from weed seeds, spreads evenly, is not blown off by heavy winds and does not smother the plants. The objects to be secured are; to protect against the bad effects of freezing and thawing; to keep the soil more moist the following spring; to prevent the ground from baking; to retard the time of blooming thus diminishing danger from late spring frosts; to keep the berries clean; to improve conditions at picking time. Various materials may be used for mulching, that most easily obtained at minimum prices ordinarily being selected, such as coarse, strawy, horse manure, marsh hay, clean wheat or oat straw, swale grass, leaves for covering small beds, or even corn stalks if nothing else is available. Oat straw smothers plants more quickly than does wheat straw and stable manure frequently introduces grass and weed seeds. The covering should be applied to the entire surface of the ground, as soon as it is sufficiently frozen to bear a wagon. A heavy mulch is unnecessary and undesirable for if too thick the plants may be smothered. A light coating an inch or two deep that covers the plants out of sight is preferable to one of greater depth.

Treatment during fruiting season.—The mulch should remain over the plants as long as possible in the spring. As warm weather approaches it may be necessary to shake up the covering to prevent the plants from smothering; if need be, remove part of the material, where too thick, to the space between the rows. The vines will grow up through the mulch left on the ground. No further treatment is generally necessary except to hand-pull the larger weeds after a soaking rain. In extreme conditions it may be necessary to remove the mulch and give thorough cultivation, replacing it before the berries ripen.

Renewing old beds.—Usually it is better to set new beds each year than to continue the old ones. The advisability of removing more than one crop of fruit depends largely on the condition of the bed. If the plants are numerous, vigorous and healthy, and the ground not too weedy they may be left for a second crop. Two and even three profitable crops may sometimes be harvested before making a change. The berries ripen slightly earlier but average somewhat smaller on the older beds, and the plants are more liable to trouble from insects and diseases. The cost of cleaning out and caring for an old bed is usually greater than for setting a new one. Under some conditions a quick growing crop maturing before winter may be grown upon the same soil if the strawberry vines be plowed under as soon as the crop has been harvested, or it may be advantageous to sow the ground to a clover cover-crop to be plowed under the following spring.

If the bed be retained for a second crop it will be necessary to clean out, fertilize and cultivate the rows. Some growers go over the bed with a mowing machine and as soon as the leaves are sufficiently dry burn over the entire field during a wind blowing in the direction of the rows. This must be carefully done or injury may result to the crowns of the plants. Such a treatment tends to lessen insect and fungus troubles. The majority of growers who retain their beds narrow down the old rows with plow, disc-harrow or cultivator to a width of from six to twelve inches depending on the stand of plants, and cultivate thoroughly to

loosen the ground which has become hard and compact from the tread of the pickers. The weeds and surplus plants should be cut out from the rows remaining and a heavy application of plant food, preferably in the form of well rotted stable manure, should be broadcast lengthwise of the rows and directly over the plants. If this work is done after the first rain following fruitage, the plants will quickly start into new growth.

Insects and diseases.—It is not the intention at this time to discuss in detail strawberry insects and fungi, although some of them may attack either leaves, crowns, roots or the fruit. They are not so numerous nor so destructive as with the other small-fruits. Reference has already been made to the danger of using sod ground on account of the white grubs, the larvæ of June bugs. Among fungus diseases, leaf-blight is most destructive to foliage, its presence being indicated by circular, light colored spots bordered with red. Good air and soil drainage, with selection of good resistant varieties aid greatly in reducing the amount of injury. In severe cases it may be necessary to spray thoroughly with bordeaux mixture using the 3-3-50 formula as growth begins in the spring and again just before blossoming time; or if an old bed, spray as soon as the rows have been cleaned out after fruiting. The best preventive of both insects and fungi in addition to the measures already suggested, is a quick rotation of crops.

Conclusion.—It must be kept in mind that the suggestions given above are not full specific directions. Details vary widely in different places and must be worked out by each grower to meet his own conditions. The subjects have been treated in a general way, indicating some of the methods pursued by a large number of successful growers.

BULLETIN No. 339.

IS IT NECESSARY TO FERTILIZE AN APPLE
ORCHARD?*

U. P. HEDRICK.

SUMMARY.

1. This bulletin is a report of a fifteen-year experiment to determine whether it is necessary to fertilize apple orchards.

2. Current recommendations for fertilizers in orchards are unreliable because there have been few investigations of the subject which have furnished trustworthy information. Present practices are largely based on the fertilization of field and garden crops, but the needs of apples cannot be compared, in the least, with the needs of herbaceous crops because of the great difference in the habits of growth of the two kinds of plants. Fertilizing apples is a difficult problem, too, for, beside variability of plant and environment to contend with, as with all plants, it is necessary to take thought of the tree and of the crop of the future.

3. This experiment has to do with apples — not apples and grass. Attention is called to this fact because most of the investigations of fertilizers for apples have been carried on with trees in sod. In all such experiments the interactions of soil, apples, grass and fertilizers are so complicated that a crucial test is impossible.

4. The experiment under discussion was carried on in a Station orchard, the soil of which is a clay loam too heavy for a good orchard soil and not better than the average clay soil in the farm lands of western New York. The orchard has been given the care it would have received in a commercial plantation.

* A reprint of Bulletin No. 339. July, 1911.

5. There are twelve plats in the experiment the arrangement of which is shown in Figure 1, page 160. The fertilizers applied each year are as follows:

Stable manure.....	Plats 1 and 9, average per tree	415.15 pounds
Acid phosphate.....	" 2 and 8, " " "	12.66 "
Muriate of potash.....	" 6 and 10, " " "	7.26 "
Acid phosphate.....		12.6 "
Muriate of potash.....	" 4 and 12, " " "	7.26 "
Acid phosphate.....		12.6 "
Nitrate of soda.....		3.67 "
Dried blood.....		12.84 "

6. An important consideration is that the fertilizers were put on only underneath the branches of the trees so that a tremendous excess of each has been used and the experiment, therefore, throws light on the question as to whether excessive fertilization is deleterious to trees.

7. The apple in the experiment is the Rome top-worked on Ben Davis, the Rome buds all having come from one tree and the stocks having been selected carefully. These precautions were taken to exclude individual variations. Cross-pollination is provided for, there being over a hundred other varieties separating and bounding the plats.

8. The results of the experiment are gaged by the yield, size, color, flavor, maturity and keeping quality of the fruit, the diameter of tree, amount, color and weight of foliage and the length and weight and the annual growth of the branches.

The fertilizers have had no sensible effects upon the yield of fruit in this experiment.

The size of the apples is possibly increased by the fertilizers since the percentage of culls and seconds is a trifle higher in the check plats.

The several current generalizations as to the effects of fertilizers on apples find no verification in this experiment.

All of the trees in the several plats have borne crops very uniform in maturity, keeping-quality, texture and flavor of apples.

A study of the tables giving the diameter of the trees in the experiment shows no differences outside the range of variation in the several plats.

The foliage in the plats receiving nitrogen was greener than in other plats during the last season, the first difference to be certainly counted as an effect of a fertilizer.

There was also a measurable effect of the nitrogen in the weight of the leaves.

There is slight evidence that the trees on plats to which nitrogen is applied are making a greater annual growth of branches.

9. The trees in this experiment would have been practically as well off had not an ounce of fertilizer been applied to them. One must conclude that if fertilizers have no value in this orchard, they have no value in many other orchards in New York.

10. From the data at hand there seems to be but one interpretation of the results of this experiment. An analysis of the soil before the experiment was begun shows that at that time there was, in the upper foot of soil, enough nitrogen per acre to last mature apples trees 183 years, of phosphoric acid, 295 years, of potash, 713 years. From this well-nigh inexhaustible storehouse, tillage, cover-crops and good care have made available all the plant food these trees needed.

11. It may be necessary to fertilize some apple orchards in New York. Such cases will be found on sandy and gravelly soils, on lands very subject to drought, on very shallow soils and on soils quite devoid of humus. Some soils may require one of the chief elements of fertility; some, though few, indeed, need the three which usually constitute a complete fertilizer.

12. A fruit-grower may assume that his trees do not need fertilizers if they are vigorous and making a fair amount of new wood. If the trees are not vigorous the drainage, tillage and sanitary condition of the orchard should be looked to first and the fertilization afterward if then found necessary. Lastly, before using fertilizers the fruit-grower should obtain positive evidence by experimentation as to whether an orchard needs fertilizers, and what ones.

INTRODUCTION.

FERTILIZING THE APPLE A DIFFICULT AND UNSOLVED PROBLEM.

Plants are extremely complex and changeful organisms and live in environments which are also extremely complex and changeful. To furnish food to them, therefore, is a difficult and an unending problem. In particular, it is perplexing to know how to nourish the apple without waste, because, beside variability of plant and environment to contend with, it is necessary to take thought for the tree and the crop of the morrow. These difficulties have seemingly driven experimenters with fertilizers to other fields where the harvest is more certain and more immediate; for there have been in the past, either at home or abroad, almost no long-continued experiments to ascertain what the fertilizer requirements of apples are. In America there have been less than a half dozen experiments, planned and carried out for more than two years, which could, without greatly expanding the imagination, be called fertilizer experiments with apples.

Having but little definite data as to fertilizer requirements for the apple, practically all the recommendations for fertilizing this fruit are based on the differences in the chemical composition of the apple-tree and crop, as compared with truck and grain crops. But the chemical composition of a crop affords only a rough approximation of its fertilizer requirements, and the needs of the apple cannot be determined for actual practice by comparing its chemical composition with that of herbaceous crops. Its habit of growth differs greatly in many ways from that of annual crops—in age of fruiting, in length of growing season, in spread of roots, in character of the product removed, in amount of water transpired and in the continuous cropping of the apple without chance for rotation. The current recommendations for fertilizing orchards, which have thus been deduced from experiments with other plants, are so at variance with experience that orchard fertilization is now a maze in which most fruit-growers lose themselves.

With the hope of letting in light on some of the phases of orchard fertilization, this Station has undertaken several experi-

ments. One of these, to test the effects of potash, acid phosphate and lime in an apple orchard, after continuing for twelve years, was discussed in Bulletin 289. Another was combined with a test of tillage and sod-mulch for the apple and is described on page 94 of the report on tillage and sod-mulch in Bulletin 314. A third experiment is now under progress in a continuation of the orchard management test just mentioned. Lastly, there is the experiment here under discussion.

INVESTIGATION.

THE PRESENT PROBLEM OUTLINED.

The problem in this experiment may be stated by amplifying a very little the question under which this bulletin is put out. Is it necessary to fertilize an apple orchard? Are the yield, color and quality of apples and the vigor, health and longevity of the trees influenced by the addition of nitrogen, phosphorus and potash? The question is whether it is necessary to add these elements to a soil such as ours, under our conditions, rather than what combination of these elements should be used, or, what quantities can be applied without waste. So, too, time, method and frequency of application, important though they may be, do not enter into this experiment except as very secondary considerations. Our ignorance of the manurial requirements of apples is so profound that the necessity of fertilizing the average orchard is still debatable. It is, therefore, proper that an attempt be made to solve this part of the puzzle first.

This experiment was planned by Director W. H. Jordan of this Station and Professor S. A. Beach, Horticulturist. The work was in the hands of Professor Beach until his removal from this Station to Ames, Iowa, in 1905, since which time it has been in the charge of the writer.

AN EXPERIMENT WITH APPLES — NOT WITH APPLES AND GRASS.

This experiment has to do with a single crop — *apples* — not *apples* and *grass*. It would seem that this statement is gratuitous; but it is called forth by the fact that nearly all of the experiments we have had in America with fertilizers for apples have been with

orchards in sod. Exactness is not obtainable in such experiments; the conclusions drawn from them are not only loose but they are deceptive. This is illustrated in an orchard under control of this Station in which nitrate of soda is wholly inert in its effects on the apple under tillage; in another half of the same orchard, all other conditions being identical, trees in sod respond markedly to this fertilizer. There is a supposition, with sufficient evidence to give weight to it, that grass exerts a poisonous effect on trees. How can it be known with trees in grass whether salutary fertilizers are beneficial as food for the trees or as counter-influences to a possible toxin? The interactions of trees, soils and fertilizers are most complex; the addition of grass multiplies the complications and makes a crucial experiment well-nigh impossible.

It is of course worth knowing that better apples can be grown in sod if fertilizers are used. But a fertilizer experiment in sod furnishes but little trustworthy evidence as to the food requirements of the apple—much needed information for the proper culture of this fruit.

THE SITE AND THE SOIL.

The orchard in which the fertilizers are being tried is situated one and one-half miles west of Seneca lake on an upland about 100 feet above the lake and 550 feet above the sea. The land is level and is now well drained. To make sure of good drainage, tile drains two and one-half feet deep and two rods apart were laid in the orchard before planting was begun in the spring of 1896. In the wettest seasons and after the heaviest showers surface water passes away within a few hours. The field had been used for a number of years before this experiment was begun, for the ordinary rotation of farm crops and had the reputation of being very good farming land in a locality somewhat noted for the productivity of its soils.

The soil is a heavy Dunkirk clay loam from twelve to eighteen inches deep, resting on a still heavier and more compact clay subsoil; this in turn rests on shale which is to be found at a depth of from ten to twelve feet from the surface. A mechanical analysis of the soil, made by Mr. J. Davison of the New York

State College of Agriculture, is given in Table I, with analyses¹ of soils from other apple regions in New York to allow of comparisons.

TABLE I.—MECHANICAL ANALYSES OF APPLE-PRODUCING SOIL TYPES IN WESTERN NEW YORK.

		Stone 2mm.	Fine gravel 0-1 mm.	Coarse sand 1-.5 mm.	Medium sand .5-.25 mm.	Fine sand .25-.1 mm.	Very fine sand .1-.05 mm.	Silt .05-.005 mm.	Clay .005 mm.
Station		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
	{ Soil...	3.86	1.64	1.54	3.76	9.44	27.06	34.11	22.37
	{ Subsoil	3.62	1.42	1.22	3.56	9.26	25.83	29.71	28.93
Niagara County	{ Soil...		0.9	4.2	3.3	6.4	13.5	52.9	18.4
	{ Subsoil		0	1.7	1.4	5.5	4.3	54.9	32.1
Livingston County	{ Soil...		1.0	4.0	4.0	13.6	19.7	45.1	12.5
	{ Subsoil		1.1	4.8	4.1	13.9	20.3	35.2	20.4
Wayne County	{ Soil...		2.58	3.74	3.44	16.26	24.70	37.90	10.98
	{ Subsoil		1.90	3.06	3.52	17.82	24.14	34.54	14.84
Cayuga County	{ Soil...		0.5	1.9	2.6	16.8	12	34.0	32.1
	{ Subsoil		tr.	1.5	1.5	9.2	6.6	40.1	40.5

Further light is thrown upon the character of the soil by the following calculations per acre foot of the chief food constituents of the Station soil made from analyses of the soil of the experimental orchard before the experiment was begun.

TABLE II.—CHEMICAL COMPOSITION OF THE FIRST FOOT OF SOIL IN THE STATION ORCHARD.

	Lbs.
Organic matter.....	142,528
Iron and alumina.....	325,480
Lime.....	21,605
Magnesia.....	29,620
Potash.....	31,015
Phosphoric acid.....	3,240
Nitrogen.....	7,318

The Station soil is not an ideal one for apples, at best not better than the average western New York clay soil for this fruit. Though well drained, the land is yet hard and heavy and much of the time unworkable, coming from the plow in great lumps

¹ Furnished by Professor E. O. Fippin of the New York State College of Agriculture.

² Slightly heavier than typical.

³ Rather coarser than typical.

⁴ Considerably heavier than typical.

hardly to be crushed. In such a soil the root-run is limited,—a fact we have had forced upon our attention in early spring when the soil is wet, by the blowing over of several trees. Manifestly, food would be better utilized by trees in a soil where the roots could develop better. Despite the physical condition of the soil, apple trees make a very fair growth and the fruit sets in abundance, but with most varieties, and the Rome, used in this experiment, is not a marked exception, the apples run small, fail to color well and do not always mature properly.

THE PLATS AND THE FERTILIZERS.

The first applications of fertilizers were made in the fall of 1899. Figure 5 shows the arrangement of plats for the experi-

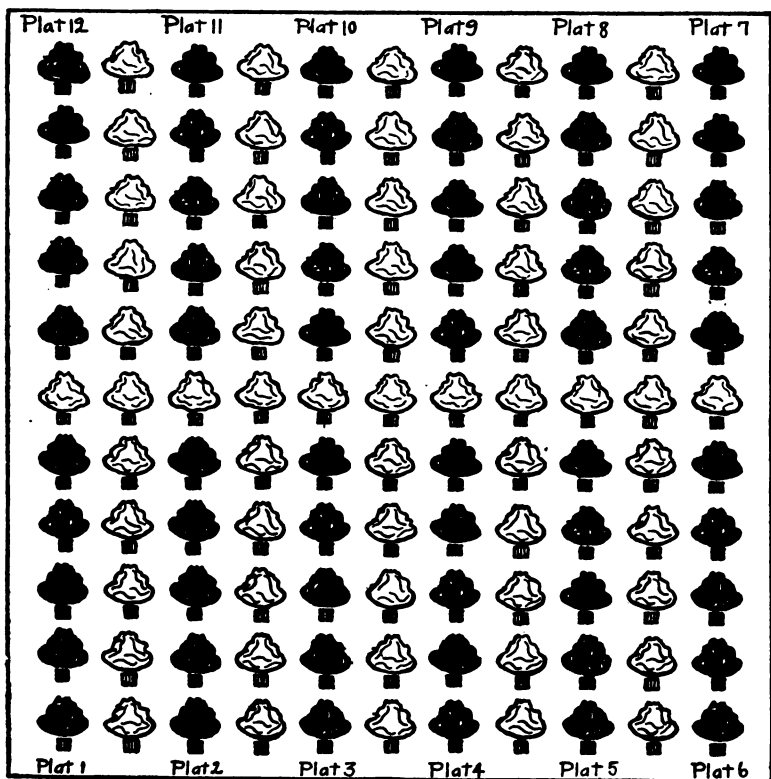


FIG. 5.—PLAN OF ORCHARD SHOWING LOCATION OF PLATS DIFFERENTLY FERTILIZED.

ment. The orchard, as the illustration shows, is divided into twelve plats, of five trees each, separated by single rows of trees not in the experiment. There are four fertilizer plats in duplicate in the experiment and four check plats. Unfortunately one of the twelve plats had to be discarded early in the experiment. Plat 7 in the southwest corner of the orchard is so near the brow of a small hill that the soil is shallower and poorer and the trees did not start off quite as well nor keep up in growth with those in the other plats. One of the trees also blew over. This plat had been intended as one of the four checks but the disparities in growth before the fertilizers had been applied, together with the accident a few years later, made it necessary to discard Plat 7 and retain but three of the checks. The remaining eleven plats were very uniform in vigor and health when the orchard received its first coating of fertilizer.

The experiment as planned calls for the use of fertilizers in the quantities commonly recommended for mature orchards, namely: 50 pounds of nitrogen per acre in stable manure on two plats; phosphoric acid at the rate of 50 pounds per acre on two plats; the same quantity of phosphoric acid plus 100 pounds of potash on two plats; with the quantities given above for the three chemicals for two other plats; and three check plats. The chemicals were applied, beginning in 1900, in fertilizers¹ and in amounts determined each year by analyses as follows:

Stable manure.....	Plats 1 and 9, average per year	415.15 lbs. per tree
Acid phosphate.....	" 2 and 8, " " "	12.6 " " "
Muriate of potash.....	" 6 and 10, " " "	7.26 " " "
Acid phosphate.....	" 6 and 10, " " "	12.6 " " "
Muriate of potash.....	" 6 and 10, " " "	7.26 " " "
Acid phosphate.....	" 4 and 12, " " "	12.6 " " "
Nitrate of soda.....	" 4 and 12, " " "	3.67 " " "
Dried blood.....	" 4 and 12, " " "	12.84 " " "

The fertilizers were put on as soon as the ground could be tilled in the spring and were distributed over an area about each tree slightly greater than that covered by the branches of the tree. The subsequent cultivations worked them in more or less deeply. The time of the applications varied a little from year to year in accordance with the weather and the availability of labor.

¹ The approximate values of the different applications per acre yearly are: Stable manure at \$2.50 per ton \$14.00; phosphoric acid \$2.25; potash and phosphoric acid \$6.50; complete fertilizer \$15.50.

AN IMPORTANT CONSIDERATION.

The plan of this experiment calls for certain amounts of nitrogen, phosphorus and potash per acre. *Since the fertilizers have been put on only underneath the branches of the trees, a tremendous excess of each has been used.* By actual measurement the branches of the trees now cover less than one-eighth of the ground area. We are, therefore, applying this year eight times as much fertilizer per acre as would be applied if the trees were mature and covered approximately the whole area. Obviously the excess was much greater in years past when the trees were smaller; probably, at the beginning, twenty-five times the amounts planned were used per acre. There has been and is much talking about the harmful effects of fertilizers when used in quantities greater than the estimates as to what the tree could use. This experiment should throw light on the time-honored belief that excessive fertilization is deleterious to trees.

THE TREES: VARIETY, PROPAGATION, SETTING, TRAINING.

The apple in this experiment is Rome top-worked on Ben Davis. The choice as to variety fell to Rome because the trees bear at an early age; are exceptionally productive; the apples are red and any influence on the color is therefore readily detected; and Rome is a late keeping sort so that the effects of the several treatments on storage qualities should show to advantage. The variety was top-worked on another apple because Rome lacks vigor. Ben Davis was used as the stock because it is very vigorous, hardy, bears early, is productive, the fruit is red and keeps well. In the last four qualities Ben Davis resembles Rome, and should there be any influence of stock on cion it would be in a desirable direction for the purposes of this experiment.

Exceeding care was taken to obtain an orchard as free from individual variation in the trees as possible. To this end the Ben Davis stocks were selected as nearly alike as trees grow in height, caliper, mode of branching and character of root system. All came from the same nursery block in which they had been set as root-grafts three years previous. To further obviate variation, the buds for the trees in the experimental orchard came from

a Rome tree of good growing and bearing habits in the Station variety orchard.

The trees in the orchard are amply cross-pollinated, though doubtfully necessary with the apple, the Rome especially, by the rows surrounding and separating the plats. In these divisional rows a variety test is being carried on with 117 varieties of apples, — 170 trees. The most ardent advocate of mixed planting for cross-pollination cannot find fault with the provisions for inter-pollination in this experiment.

Figure 6 shows a typical Ben Davis tree as it came from the nursery — about six and one-half to seven feet in height and from three-fourths to seven-eighths inch in diameter at the collar. When pruned for planting the trees averaged four and one-half feet in height. The work of transplanting was done in the spring of 1896 and beyond a somewhat severe drought there was no hindrance to the proper starting of the young orchard. The trees were set forty feet apart each way. The Romes were top-worked on the Ben Davis stocks, by budding, the last three days in July, 1896. Figure 7 shows the tree in Figure 6, budded, with the branches cut back to the buds in the spring of 1897. Figure 8 shows the same tree pruned in the spring of 1898.

It is very important that the reader take into account the

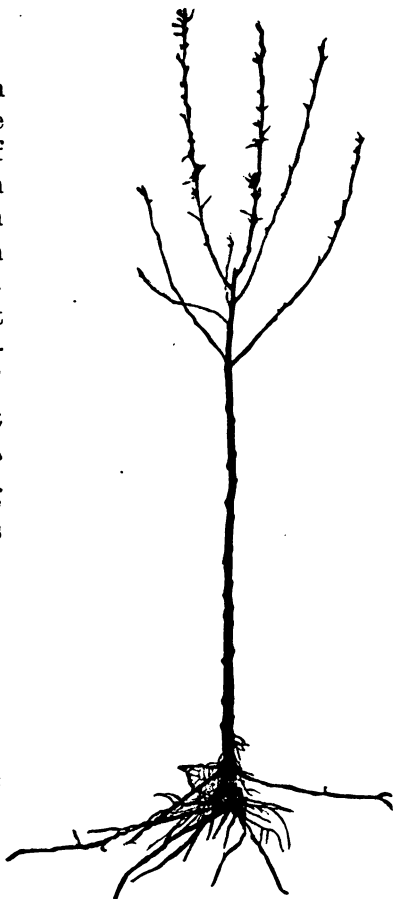


FIG. 6.— BEN DAVIS TREE FROM NURSERY, 1896.

severe pruning to which these trees have been subjected, made necessary by the top-working and by the desire to have a high

headed tree. Cutting back the Ben Davis stocks to the Rome buds and the subsequent severe pruning for several seasons to obtain a well formed head and a long trunk, on the average about five feet from the lowest branch to the ground, in the opinion of the writer, delayed the bearing time of this orchard at least three years. Figure 9 is the same tree shown in the preceding illustrations but taken in October, 1899, two years



FIG. 7.—SAME TREE BUDDED;
PRUNED FOLLOWING YEAR, 1897.

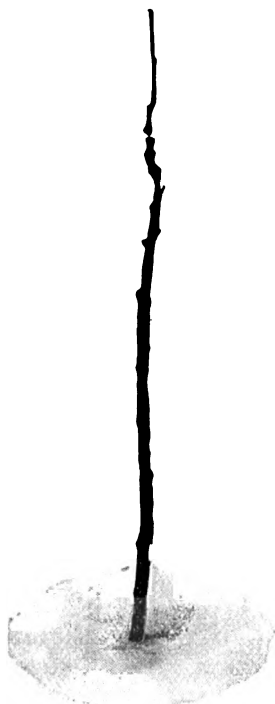


FIG. 8.—TREE IN FIG. 7 WITH
BRANCHES CUT BACK, 1898.

after budding. A glance shows that the amount of wood to be taken out is considerable if a well-formed head is to be obtained.

The great number of relatively small branches produced in all over-pruned trees, especially those that have been top-worked, thus bringing about faults of the head to be corrected; or those that have been severely cut back to secure a high head, is shown in Figure 10 from a photograph taken December 18, 1901, and

Figure 11 from a photograph taken December 19, 1902. This digression from fertilizers to pruning is made not only to account for the late bearing of the trees under discussion and to illustrate

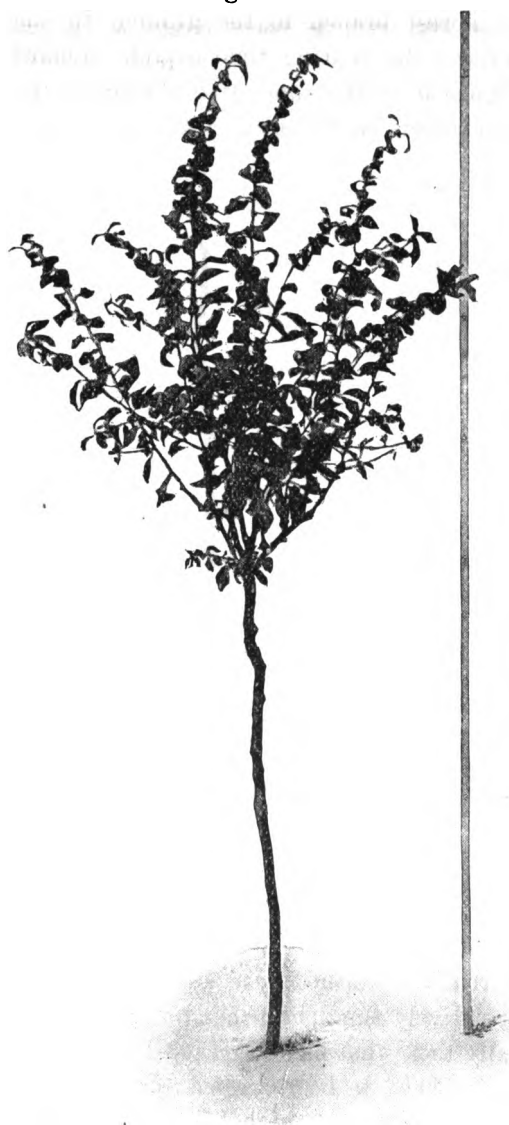


FIG. 9.—SAME TREE IN OCTOBER, 1899.

the steps in the development of this experimental orchard, but to show the effects of high-heading and top-working, both practices which the writer does not advocate.

The further development of the orchard is shown by Plate XVII, made from a photograph taken on September 26, 1905; Plates XVIII and XIX from photographs of October, 1910; and Plate XX illustrating the orchard just before plowing in the spring of 1911. The trees have been pruned as little as possible during the past six years with the hope that the bearing period might not be

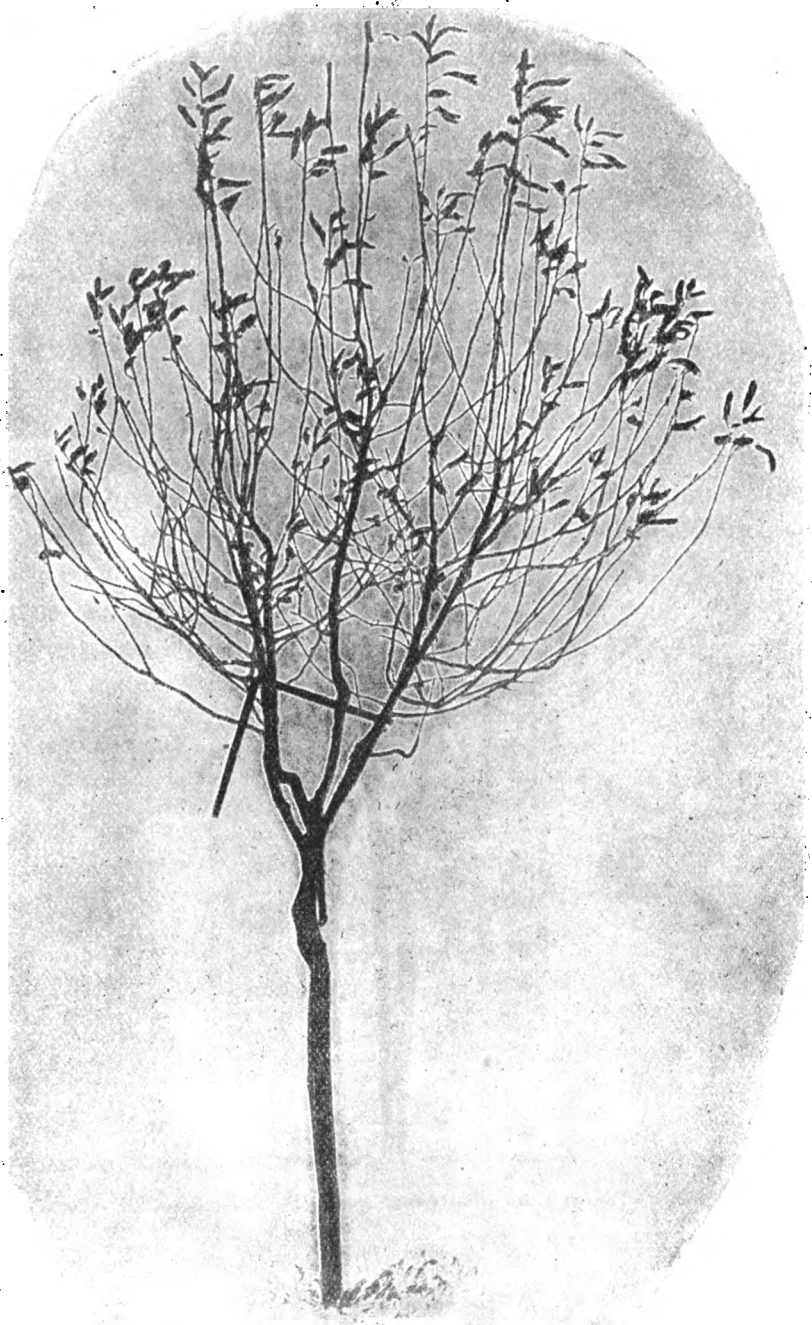


FIG. 10.—SAME TREE, DECEMBER, 1901.

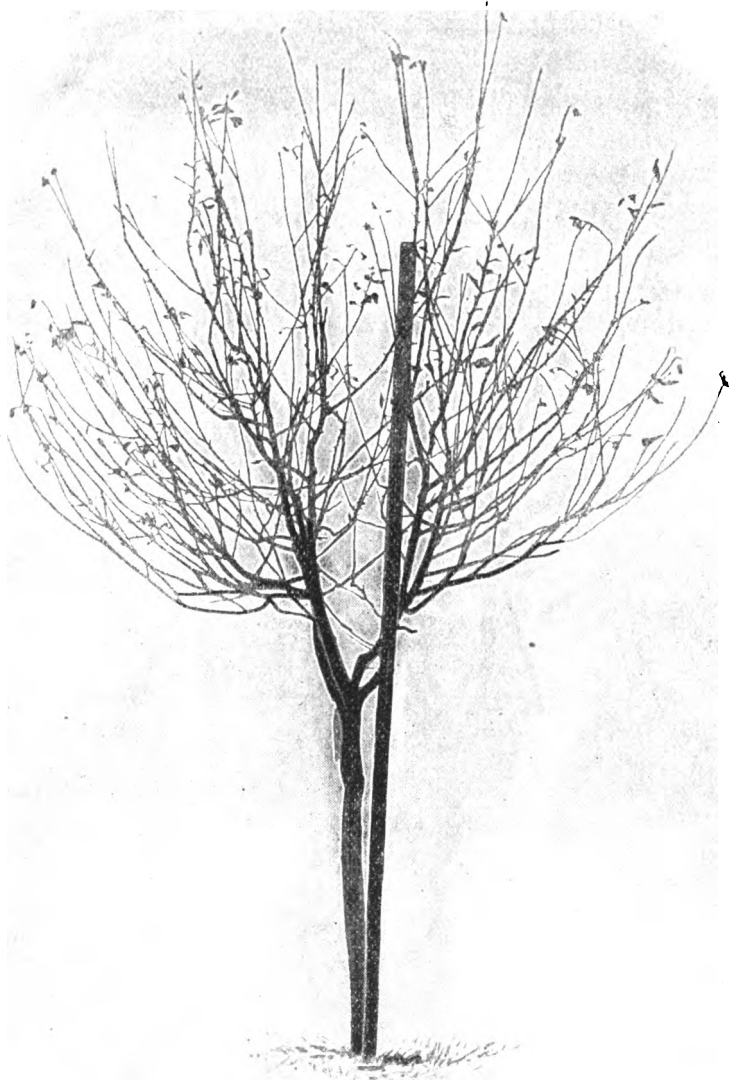


FIG. 11.—SAME TREE, DECEMBER, 1902.

further delayed. In this later pruning, all that has been done has been to cut out crossed and injured branches, and these have been few, until the past winter, when the tops had become so very thick that they were thinned somewhat.

Every season since 1904, the trees have been sprayed for San José scale with lime and sulphur with one exception, discussed on p. 269, when a miscible oil was used. Since 1900 the trees have been regularly sprayed with bordeaux mixture and an arsenite at the times and in the manner practiced in commercial orchards.

CARE OF THE ORCHARD.

The aim has been to give the trees in this experiment the same care they would have received in a commercial plantation. The tillage has consisted of an early spring plowing, cultivation once in ten days or two weeks until the last of July, followed by a cover crop. Since leguminous cover crops would have added an unknown and variable amount of nitrogen to the soil, legumes have not been used. The cover crops grown, with a record of the time of planting and plowing under, are as follows:

COVER-CROPS IN EXPERIMENTAL ORCHARD.

YEAR.	Crop.	Sown.	Plowed under.
1896.....	Rape.....	Aug. 1.....	June 1.
1897.....	Wheat.....	Oct. 1.....	.....
1898.....	Rye.....	Aug. 12.....	May 20.
1899.....	Rye.....	.....	May 9.
1900.....	Rye.....	Sept. 24.....	May 28.
1901.....	Rye.....	Oct. 1.....	May 21.
1902.....	Rye.....	Sept. 13.....	May 13.
1903.....	Oats.....	July 30.....	June 4.
1904.....	Rye.....	Oct. 18.....	May 19.
1905.....	Barley.....	Sept. 8.....	May 8.
1906.....	Barley.....	July 21.....	May 1.
1907.....	Oats.....	Aug. 6.....	May 2.
1908.....	Rye.....	Oct. 5.....	May 19.
1909.....	Rape and cow horn turnip	Aug. 19.....	April 13.
1910.....	Barley and cow horn turnip	Aug. 6.....	April 27.

The rather extreme variations in the dates of planting and plowing under the cover crops are due to weather conditions and inability to command labor when the work needed to be done.

UNUSUAL CONDITIONS AFFECTING THE EXPERIMENT.

There were the usual seasonal fluctuations of temperature and humidity during the fifteen years of this experiment but there have been no meteorological conditions having any very unusual influence on the trees. If the fifteen years be compared with the fifteen just preceding¹ it will be found that the recent period is a much more favorable one for tree growth than the former one. In particular the last ten years have been favorable to the growth of trees and to fruit-bearing, there being no year in the decade that there has not been an average growth for apple trees and an average crop of apples in western New York.

The orchard, in common with all orchards in this part of the State, suffered severely during one season from an insect and another from disease. In the summer of 1903 there was a severe outbreak of apple aphid in New York and despite four sprayings with whale oil soap the trees were much injured by this pest. In June, 1906, there was an uncontrollable epidemic of blight in New York and all of the trees in this experiment were attacked by the disease and suffered terribly in both the new and old wood, the trees losing at least ten per ct. of their tops. The orchard has also suffered from an unfortunate accident. By mistake, the trees were experimentally sprayed with one of the miscible oils in the winter of 1907, wholly destroying the fruit-buds and many of the leaf-buds for that year. In all three of these disasters, however, the trees in the orchard were injured in equal degree so that the comparisons have not been materially changed by them. Two were calamities that occurred to all orchards in New York and there are but few orchards that do not suffer from some accident

¹ See U. P. Hedrick, Relation of Weather to Setting of Fruit, *N. Y. Sta. Bul.* 299. 1908.

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PLATE XVII.—TREE IN FIGS. 6-11, PHOTOGRAPHED IN SEPTEMBER, 1905.

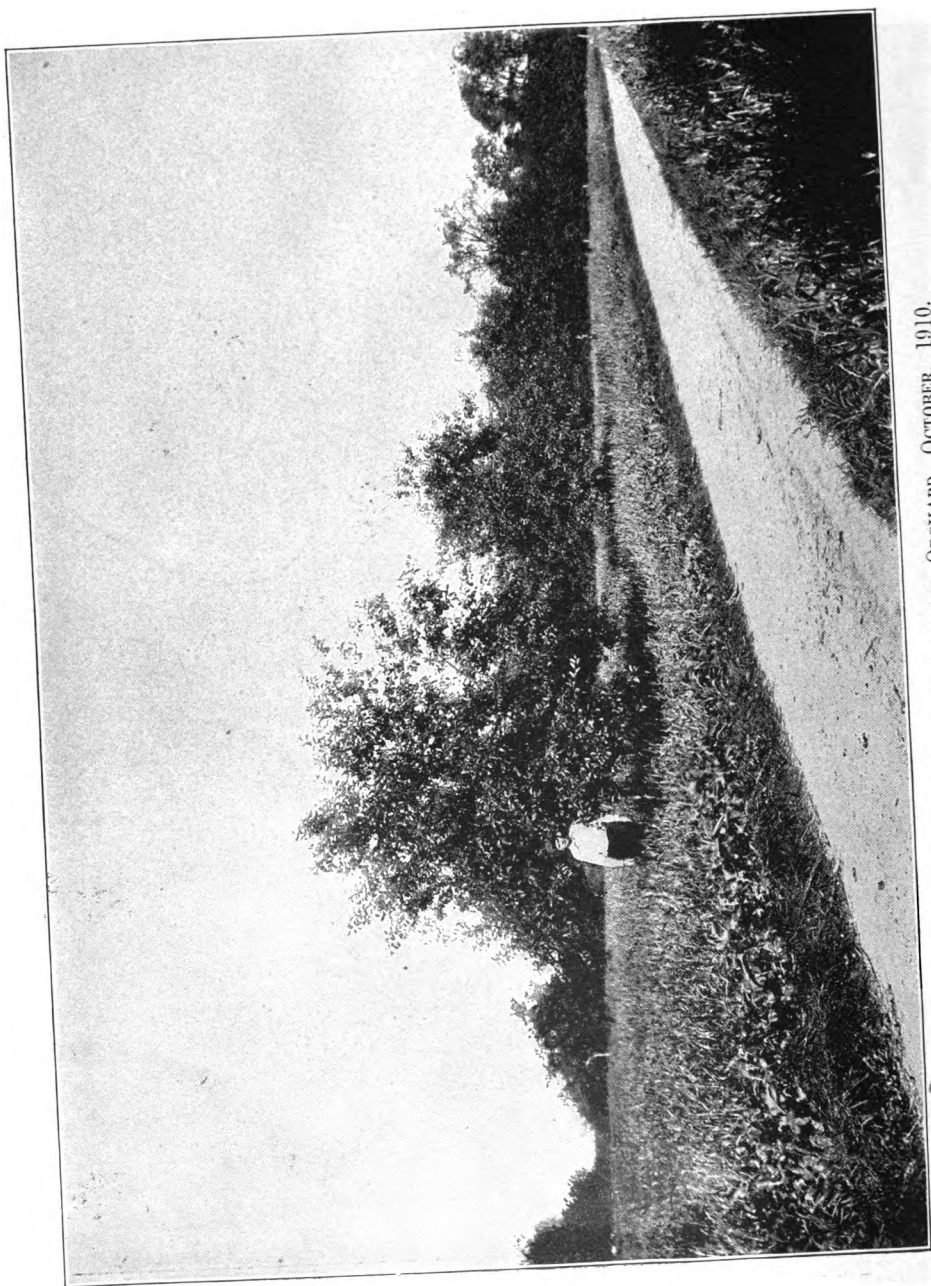


PLATE XVIII.—TREE AND SECTION OF ORCHARD, OCTOBER, 1910.

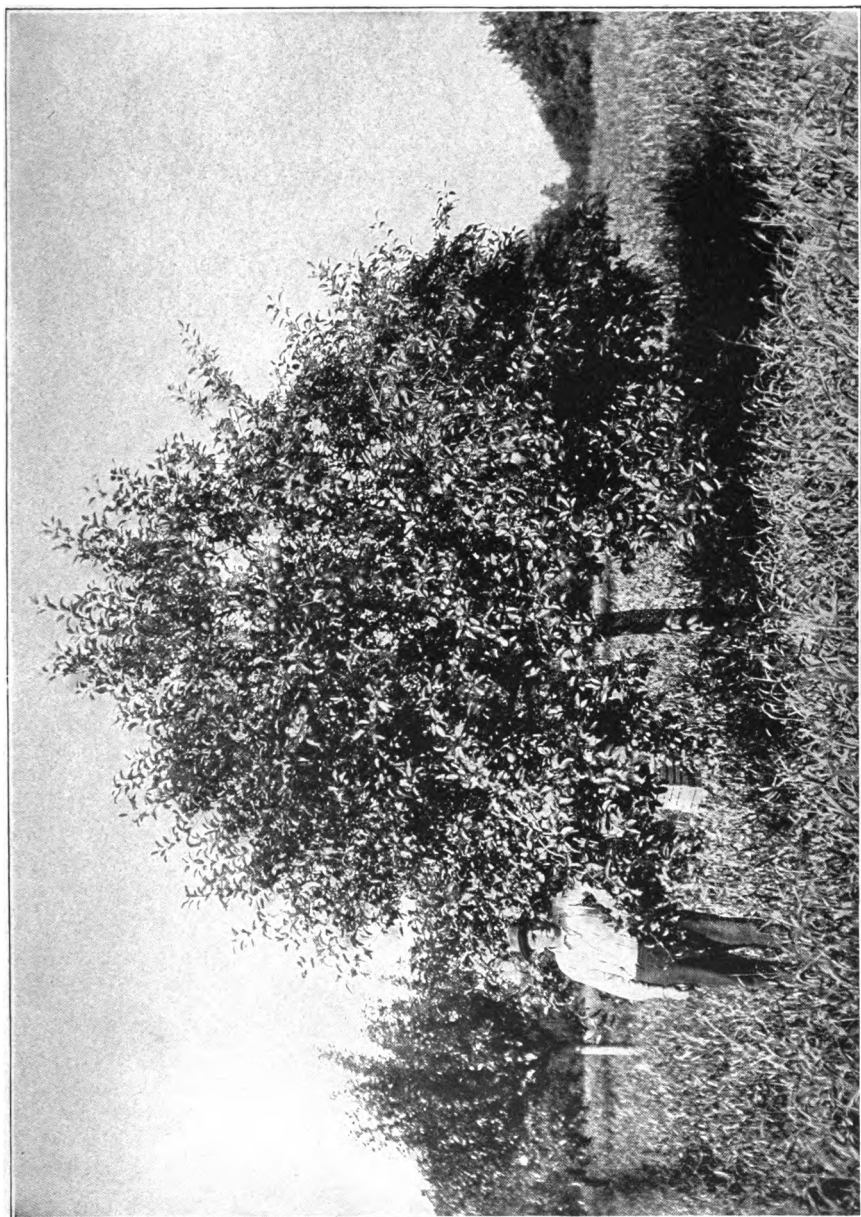


PLATE XIX.—CLOSER VIEW OF SAME TREE, OCTOBER, 1910.

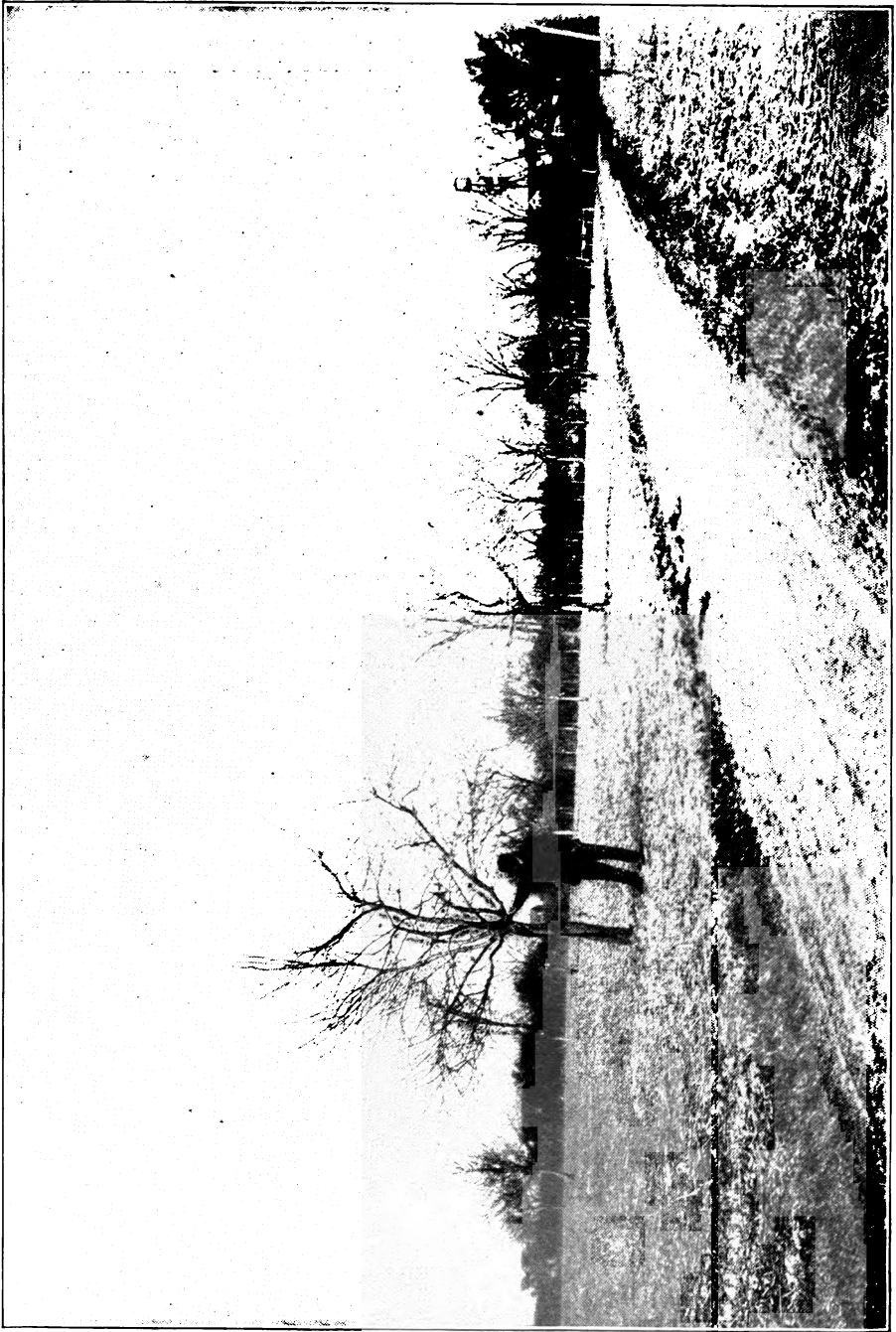


PLATE XX.—SAME TREE BEFORE PLOWING ORCHARD IN SPRING, 1911.

in the course of fifteen years so that these trees can hardly be said to be abnormal because of the unusual circumstances in their lives.

RESULTS.

FACTORS CONSIDERED.

In gaging the value of fertilizers it is imperative that both fruit and tree be considered. Too often fruit alone is used to measure the value of a fertilizer and not infrequently only the yield of fruit is used. While fruit-bearing is the most important character it is so subject to extrinsic influences and consequent large accidental variations that it becomes necessary to use all characters of fruit and tree in determining the influence of a fertilizer. In the fruit, not only yield but size, color, flavor, time of maturity, texture of flesh, and keeping quality must be considered. For the measure of tree vigor there are also several characters available. Those we have chosen for this experiment are diameter of tree, color and weight of foliage, and the length and weight of the annual growth of the branches. All of these criteria taken separately are open to some objections — even when taken together it is impossible to draw wholly satisfactory deductions.

EFFECTS OF FERTILIZERS ON THE FRUIT.

Yield of fruit.—In Table III the amounts of fruit borne in the different plats for each year of this experiment are given, with averages per tree for all of the crops borne. The yearly yields of individual trees in the experiment, with the averages per tree, are given in Table IV.

The tables need little amplification. The orchard bore its first crop of fruit in 1902, when the trees were in their seventh year, and has borne six crops since. An examination of the figures in Table III for the eleven plats shows that the fertilizers have had no sensible effects upon the yield of fruit in this experiment; and the figures in Table IV, for the individual trees, emphasize this conclusion. If two or three seasons in this fifteen-year experiment be considered as a single period, advantages might be claimed for

some one or another of the plats, but when a longer period, or the total, is considered, the advantage is in every case contradicted — incidentally these contrarieties show the necessity of a long-time experiment with fertilizers for apples.

Total crop production is not the fairest criterion of the value of the treatment of the different plats in this experiment; for, the 1910 crop is nearly as large as the six other crops combined and a variation from some cause other than the fertilizers in this one season destroys the value of the total crop figures. A fairer criterion is the average rank of the plats as to productivity for the seven years. So gaged, we find that the plats rank as follows: Stable manure was third in productivity three times, fourth three times and fifth once. The phosphoric acid plat in two seasons was most productive, once second, three seasons fifth and once fourth in productivity. The plat to which potash and phosphoric acid were applied was twice most productive, twice second in productivity, once third, once fourth and once fifth. The complete fertilizer plat yielded most fruit only one year, was twice second on the list, twice third, once fourth, and once fifth. The differences between the plats represented in the above figures are so small, however, that they do not prove in the least the superiority of one treatment over the other.

TABLE III.—YIELD OF FRUIT FROM DIFFERENT PLATS IN ORCHARD FERTILIZER EXPERIMENT.

FERTILIZERS.	1902.	1903.	1905.	1906.	1908.	1909.	1910.	Average per tree.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Stable manure.....	27.85	71.64	597.73	215.73	1,822.98	288.62	3,308.60	90.47
Phosphoric acid.....	15.79	119.59	545.46	238.67	1,950.09	325.00	2,936.24	87.57
Phosphoric acid and potash.....	42.03	90.65	556.39	137.17	1,930.17	622.74	3,855.48	103.34
Phosphoric acid, potash and nitrogen.....	53.59	67.34	644.71	203.28	1,914.23	496.55	3,658.09	99.10
*Check.....	60.95	145.45	1,029.50	358.10	2,589.37	752.97	4,750.84	92.25

* Yearly yields are from fifteen trees; ten trees in all other plats.

TABLE IV.—YEARLY YIELDS OF INDIVIDUAL TREES IN ORCHARD FERTILIZER EXPERIMENT.

	LOCATION.		1902.	1903.	1905.	1906.	1908.	1909.	1910.	Total.
	Row No.	Tree No.								
Plat 1. Stable manure.....	1	1	Lbs. 9.06	Lbs. 3.50	Lbs. 66.56	Lbs. 20.25	Lbs. 211.00	Lbs. 21.75	Lbs. 368.25	Lbs. 700.37
	2	1	1.50	5.93	97.43	26.12	259.87	42.50	421.75	855.10
	3	1	.37	28.43	87.75	40.62	244.31	15.00	482.62	899.10
	4	1	.....	.68	29.00	13.25	107.37	15.00	219.25	384.55
	5	1	3.37	.....	90.06	43.62	233.25	42.50	429.00	901.80
Plat 9. Stable manure.....	7	7	6.06	16.25	85.12	18.25	185.50	20.00	319.62	650.80
	8	7	6.62	8.18	61.75	19.12	168.50	26.00	314.12	604.29
	9	7	.....	1.68	49.25	17.00	128.00	43.00	283.75	522.68
	10	7	.87	2.06	12.75	6.50	102.75	27.00	242.37	394.30
	11	7	.....	4.93	18.06	11.00	122.43	35.87	227.87	420.16
Average per tree.....	.....	.....	2.78	7.16	59.77	21.57	182.29	28.86	330.86	633.31
Plat 2. Phosphoric acid.....	1	3	5.81	.56	35.62	11.87	184.25	36.50	242.87	517.48
	2	3	1.25	.....	96.68	44.75	356.37	11.50	488.50	999.05
	3	3	.56	22.43	71.00	42.00	241.81	23.00	431.25	832.05
	4	3	.....	13.81	76.37	28.12	208.00	22.50	129.37	478.17
	5	3	1.56	52.31	123.75	61.81	229.75	25.50	382.25	876.93
Plat 8. Phosphoric acid.....	7	9	1.43	12.62	10.81	8.25	166.62	34.50	292.00	528.23
	8	9	.....	.....	17.00	10.87	75.00	16.50	126.75	246.12
	9	9	3.62	8.93	60.62	21.25	222.18	56.00	410.50	783.10
	10	9	.....	8.93	15.43	5.00	105.93	48.50	149.25	333.04
	11	9	1.56	.....	38.18	4.75	160.18	50.50	283.50	538.67
Average per tree.....	.....	.....	1.57	11.95	54.54	23.86	195.00	32.50	293.62	613.08

TABLE IV.—YEARLY YIELDS OF INDIVIDUAL TREES IN ORCHARD FERTILIZER EXPERIMENT.—(Concluded)

	LOCATION.		1902.	1903.	1905.	1906.	1908.	1909.	1910.	Total.
	Row No.	Tree No.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Plat 6. Phosphoric acid and potash....	1	11	7.68	4.43	59.62	14.87	252.00	137.87	466.50	942.97
	2	11	9.12	.....	81.18	7.00	196.37	80.50	330.25	713.42
	3	11	3.25	3.25	21.87	12.37	108.00	43.50	291.12	483.36
	4	11	14.12	10.68	98.43	16.00	264.00	88.50	531.12	1,022.85
	5	11	.56	7.31	48.68	5.25	123.00	36.37	372.00	593.17
Plat 10. Phosphoric acid and potash....	7	5	1.31	10.18	31.37	22.43	289.37	45.50	486.75	886.91
	8	5	1.37	8.81	66.50	17.75	120.00	49.00	304.62	568.05
	9	5	.50	8.25	59.75	13.00	168.75	48.00	416.75	715.00
	10	5	4.12	22.06	47.37	7.50	299.00	40.50	411.00	831.55
	11	5	.....	15.68	41.62	21.00	109.68	44.00	245.37	477.35
Average per tree.....	.....	.....	4.20	9.06	55.63	13.71	193.01	62.27	385.54	723.46
Plat 4. Phosphoric acid and potash and nitrogen.....	1	7	15.43	1.75	109.87	23.12	326.00	60.50	516.62	1,053.29
	2	7	6.25	1.68	96.68	33.12	272.62	67.50	465.37	943.22
	3	7	4.43	3.93	66.37	11.12	120.00	47.50	449.75	703.10
	4	7	.....	.25	7.18	4.00	53.00	27.18	212.50	304.11
	5	7	3.43	30.62	116.31	40.25	260.00	34.00	401.25	885.86
Plat 12. Phosphoric acid and potash and nitrogen.....	7	1	.68	12.12	29.31	16.12	151.68	28.37	191.87	430.15
	8	1	2.50	1.00	33.25	11.50	88.25	38.50	100.12	275.12
	9	1	9.75	14.56	90.93	18.43	277.00	35.00	521.87	967.54
	10	1	11.12	.....	81.50	35.12	280.68	75.00	571.87	1,055.29
	11	1	.....	1.43	13.31	10.50	85.00	83.00	226.87	420.11
Average per tree.....	.....	.....	5.35	6.73	64.47	20.32	191.42	49.65	365.80	703.77

Plat 3. Check.....	1	5	.....	.....	15.68	12.00	98.25	39.50	146.62	312.05
	2	5	4.37	6.43	91.93	16.75	185.00	27.18	331.50	663.16
	3	5	3.81	10.56	130.06	17.75	256.00	34.18	288.75	741.11
	4	5	2.56	7.56	81.62	30.50	207.87	23.37	374.12	727.60
	5	5	15.37	38.68	131.81	39.75	290.25	55.00	550.62	1,121.48
Plat 5 Check.....	1	9	3.12	3.75	56.00	6.50	168.00	101.37	233.37	572.11
	2	9	1.93	1.87	70.18	35.37	156.00	26.00	370.00	661.35
	3	9	4.93	.....	62.87	24.87	144.00	63.00	343.75	643.42
	4	9	.....	.....	35.25	18.50	117.00	36.87	207.37	414.99
	5	9	1.93	27.37	68.62	20.87	121.50	53.00	261.75	555.04
Plat 11. Check.....	7	3	.....	.37	18.62	22.75	76.00	15.50	126.25	259.49
	8	3	7.00	8.56	52.00	22.50	123.25	70.50	241.25	525.06
	9	3	7.06	16.18	80.93	37.12	216.00	87.50	422.37	867.16
	10	3	8.81	12.87	86.75	32.62	235.00	36.00	527.50	939.55
	11	3	.....	11.25	47.18	20.25	195.25	84.00	325.62	683.55
Average per tree.....	.....	.....	4.06	9.69	68.63	23.87	172.62	50.19	316.72	645.80

Size of apples is possibly increased by the fertilizers.—Table V is a comparison of the first, second and cull apples in the different treatments in 1910. All apples between two and one-half and two and one-quarter inches are seconds, under two and one-quarter inches, culls. This harvest possibly shows an influence of the fertilizer. Table V gives the percentage of seconds for the check plats a trifle higher than the average and the percentage of culls higher than the maximum. The differences, however, are very slight and unless future crops show the same falling off in size for the checks, increased size must not be counted as an asset for the fertilizers in the experiment up to the present, but rather as an accidental variation. Table VI shows a greater number of apples on the check plats.

TABLE V.—YIELDS OF FIRST, SECOND AND CULL APPLES, 1910, IN ORCHARD FERTILIZER EXPERIMENT.

FERTILIZERS.	Firsts.	Seconds.	Culls.	Percentage of seconds.	Percentage of culls.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>		
Stable manure.....	3,160.8	107.7	40.3	3.2	1.2
Phosphoric acid.....	2,784.5	105.7	46.1	3.6	1.6
Phosphoric acid and potash.....	3,585.5	187.0	83.0	4.9	2.1
Phosphoric acid and potash and nitrogen.....	3,421.5	168.2	68.5	4.6	1.8
*Check.....	4,407.6	216.4	98.8	4.6	2.9

* Fifteen check trees; ten in all other treatments.

TABLE VI.—WEIGHT OF APPLES IN 1910, DIFFERENT PLATS OF ORCHARD FERTILIZER EXPERIMENT.

FERTILIZERS.	Number of apples.	Average weight per apple.
		<i>Ounces.</i>
Stable manure.....	1,134	6.4
Phosphoric acid.....	1,163	6.1
Phosphoric acid and potash.....	1,126	6.3
Phosphoric acid and potash and nitrogen.....	1,115	6.5
Check.....	1,748	6.2

The value of the tables showing the differences in the size of the fruits from the several plats is greatly reduced because we do not know how to interpret the facts shown. It is an open question as to whether the size of individual apples or the number of fruits is the more accurate measure of the vigor of the trees and therefore of the plant food used. Small apples contain as many seeds, and a relatively larger amount of dry matter than large apples. Total quantities being the same, then, small apples should have exhausted the soil more than large ones. But the figures given in the several tables do not fit this theory, nor any other, thus strengthening the supposition that the differences are but expressions of accidental variations.

The fertilizers exert no influence on the color of fruit.—It is commonly thought that the color of fruits can be modified by the use of fertilizers. This phase of the experiment was therefore approached with much interest. The clay soil in this orchard is a very favorable one upon which to try to influence color since it is common knowledge that apples take on bright colors on sandy soils and run to dull or green hues on clays.

The annual notes on color for these seven crops of apples can be summed up with the expression for each crop, "No differences in color can be noted." The apples were looked at in different quantities, in different lights, at varying intervals after being put in storage, and by several persons, with the invariable conclusion that the color was the same on the fruits of all the plats. The coloring has varied more or less from year to year but not at all with the different treatments. Color in fruit in New York is usually an indication of vigor in a tree. Other things being equal the more vigorous the tree, with a red apple like the Rome, the more green is the fruit. The fact that the fruits in the several plats in this experiment are all colored alike is another proof that the fertilizers have not affected the growth of these trees.

The popular generalizations as to the effects of fertilizers on the color of fruits, as "potash paints fruits," and "manure makes green apples," find no verification in this experiment.

Effects on maturity, keeping-quality, texture and flavor of apples.—There is a general supposition that all of the qualities named in the heading of this paragraph are more or less affected by fertilizers. Facts to bear out such a supposition usually arise as the vigor of the tree is influenced. Great vigor in a tree delays maturity somewhat, thereby producing a better keeping apple, and influences favorably the texture and flavor of the apple by making the flesh more juicy and crisp. These effects of vigor were very manifest in an experiment carried on by this Station in comparing tillage and sod-mulch in an apple orchard.¹ But in none of these qualities were there noteworthy differences in the apple growth under the several treatments in this experiment. Very commonly, in comparison of orchard management methods, the flesh of the apple shows the result of some disturbance of the “protoplasmic gearing” in the production of dry or corky spots in the flesh, in water-coring or in a tendency to mealiness. There have been no such manifestations of physiological trouble in any of the plats in this experiment. The great uniformity in the product of all of the trees seems to point to the conclusion that the fertilizers have had trifling or no effects.

INDIVIDUALITY OF TREES.

The advocates of individuated strains of fruits may find valuable material for buttressing their theories in the yields given for individual trees in Table III. There is food for thought as one notes the wide variations in the performance of individuals in the several plats of this experiment and remembers that all of the trees came from buds from a single tree. Can the yield performance of the best trees, as shown by the table, be transmitted to trees propagated from them? There has been no precise experimenting and but little precise thinking on the subject of individuated strains of fruits now so much before fruit-growers. The writer fears that the data given here, if used to substantiate any of the current theories, would but add to existing inexactness and in-

¹ Hedrick, U. P. A Comparison of Tillage and Sod-Mulch in an Apple Orchard. *N. Y. Sta. Bul.* 314:98-102.

definiteness. This experiment, while suggestive, does not warrant the conclusion that there are great differences in the disposition of trees in fruitfulness. Fruit-bearing is hardly an established habit of the orchard as yet; and the trees have not recovered from top-working and over-pruning and the consequent upsetting of natural habits. The lack of uniformity in the yields of the trees in the several plats in this experiment is probably most largely due to outside influences. In all other characters these trees seem to be chips of the old block. Experimenters, fruit-growers and nurserymen are not distinguishing sharply enough between what is due to "nature" and what is due to "nurture" in the "individuality," "tendency" or "character"—phrase it as you will, none are precise—of trees. This inexactness is leading to much fallacious endeavor in perpetuating fruits as "pedigreed stock."

EFFECTS OF THE FERTILIZERS ON TREE CHARACTERS.

Crop performance is the ultimate measure of soil treatment in an orchard. But in a period of so few years as the one in which the orchard under experiment has been in bearing; it is possible for the trees to bear large crops at the expense of vigor and therefore curtail future bearing capacity; variations in the amounts of fruit may also arise from other causes than the supply of food.

It is necessary, then, to consider the effects of the several fertilizers on tree growth. In doing so, as many characters of the tree must be used as possible, for all may not respond in the same degree to the treatment. If the characters for measuring tree vigor have been well chosen and if accurate methods have been used, there should be close agreement in the growth of different parts of trees as affected by the several treatments. Thus, as we have seen, in fruit characters there has been nearly perfect agreement as to the influence of the different fertilizers. It will be interesting to note whether the trees have responded in like agreement.

Diameter of trees.—Probably the best tree character by which to measure vigor, especially over a long series of years, is the diameter of the trunk. From a cross-section of a tree one can tell

very accurately of the fat and lean seasons in its life by the thickness of the rings. The increase in the diameter of the trunk is thus in direct proportion to the vigor of the tree. Unfortunately it is somewhat difficult to secure a high degree of accuracy in applying this test of vigor. Tree trunks are by no means perfect cylinders, and in taking the diameters it is hard to decide where the measurement should be taken.

In this experiment, after various preliminary trials, two measurements were made on each trunk from which an average was drawn. The diameter was taken one foot from the ground and again four feet above the ground. The summarized averages are shown in Table VII and the measurements for individual trees are shown in Table VIII. A critical study of the two tables shows no differences outside the range of accidental variation. In the mind of the writer the evidence afforded by the tree trunks in this experiment is the clearest cut of any offered. One trained in statistical niceties can juggle the figures of fruit-yields and make them prove several things, but there is little opportunity for juggling with the figures from the tree-trunks.

TABLE VII.—SUMMARY OF INCREASE IN DIAMETERS OF TREE TRUNKS IN ORCHARD FERTILIZER EXPERIMENT.

FERTILIZER.	Diameter in 1905.	Diameter in 1910.	Gain.
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
Stable manure.....	3.85	6.26	2.41
Phosphoric acid.....	3.58	5.98	2.40
Phosphoric acid and potash.....	3.86	6.35	2.49
Phosphoric acid, potash and nitrogen.....	3.75	6.18	2.43
Check.....	3.73	6.14	2.41

TABLE VIII.—INCREASE IN DIAMETERS OF TREE TRUNKS IN ORCHARD FERTILIZER EXPERIMENTS.

FERTILIZER.	Row.	Tree.	Dia. in 1905.	Dia. in 1910.	Gain.	FERTILIZER.	Row.	Tree.	Dia. in 1905.	Dia. in 1910.	Gain.
			Inches.	Inches.	Inches.				Inches.	Inches.	Inches.
Plat 1. Stable manure.	1	1	4.25	6.62	2.37	Plat 6. Phosphoric acid and potash.	1	11	4.24	6.75	2.51
	2	1	4.25	6.62	2.37		2	11	4.00	6.25	2.25
	3	1	3.93	6.68	2.75		3	11	3.75	6.56	2.81
	4	1	3.81	6.06	2.25		4	11	4.18	6.98	2.80
	5	1	3.68	6.02	2.34		5	11	3.87	6.25	2.38
Plat 9. Stable manure.	7	7	3.74	6.37	2.63	Plat 10. Phosphoric acid and potash.	7	5	3.75	6.31	2.56
	8	7	3.68	6.12	2.44		8	5	3.75	6.31	2.56
	9	7	4.06	5.81	1.75		9	5	3.74	6.37	2.63
	10	7	3.43	6.12	2.69		10	5	3.99	5.87	1.88
	11	7	3.68	6.18	2.50		11	5	3.37	5.56	2.19
Average...	.....	.....	3.85	6.26	2.41	Average...	.....	.....	3.86	6.35	2.49
Plat 2. Phosphoric acid.	1	3	3.74	6.15	2.41	Plat 4. Phosphoric acid, potash and nitrogen.	1	7	4.25	6.68	2.43
	2	3	3.87	6.56	2.69		2	7	3.93	7.00	3.07
	3	3	3.87	6.56	2.69		3	7	4.18	6.56	2.38
	4	3	3.56	5.81	2.25		4	7	3.25	5.37	2.12
	5	3	3.46	6.49	2.43		5	7	4.00	6.37	2.37
Plat 8. Phosphoric acid.	7	9	3.37	5.87	2.50	Plat 12. Phosphoric acid, potash and nitrogen.	7	1	3.24	5.93	2.69
	8	9	3.18	5.31	2.13		8	1	3.24	5.00	1.76
	9	9	3.62	6.12	2.50		9	1	3.99	6.68	2.69
	10	9	3.25	5.50	2.25		10	1	4.06	6.68	2.62
	11	9	3.31	5.50	2.19		11	1	3.37	5.56	2.19
Average...	.....	.....	3.58	5.98	2.40	Average...	.....	.....	3.75	6.18	2.43
Plat 3. Check.	1	5	3.08	5.59	1.91	Plat 5. Check.	1	9	3.81	5.99	2.18
	2	5	3.81	6.31	2.50		2	9	3.62	6.68	3.06
	3	5	4.24	6.18	1.94		3	9	3.00	5.43	2.43
	4	5	3.81	6.25	2.44		4	9	3.49	5.87	2.38
	5	5	4.31	6.93	2.62		5	9	3.06	5.25	2.19
Plat 11. Check.	7	3	3.68	5.81	2.13	Average...	7	3	3.68	5.81	2.13
	8	3	4.12	6.59	2.47		8	3	4.12	6.59	2.47
	9	3	3.62	6.25	2.63		9	3	3.62	6.25	2.63
	10	3	3.73	6.14	2.41		10	3	3.73	6.14	2.41
	11	3	3.73	6.14	2.41		11	3	3.73	6.14	2.41

The foliage.—When light falls upon the green coloring matter of the leaf, plant machinery is set in motion which makes new compounds out of water and carbon dioxide and combines them with nitrogen and other elements. The material so made becomes living matter. The leaf in this complex work responds to every change in the condition of the plant and is especially responsive to the materials which it assimilates and transforms into organic matter. Yet because of the countless number, and since there is great variation in individual leaves, it is exceedingly difficult to measure accurately the changes that take place in the foliage through changes in the diet of the plant. Very largely reliance must be placed upon the observation of the experimenters. Leaves are, however, so delicate an index of the state of nutrition of a plant that a practiced eye can be relied upon to tell how well a tree is nourished from leaves even though to the untrained eye they look “all the same.”

Color of foliage.—As good a gage to the vigor of a tree as any of the characters of the leaf, is the color. The leaves of a well-fed, healthy, vigorous tree are a dark rich green. With even a slight departure from good-feeding, health and vigor, the foliage takes on a lighter color varying toward yellow. To an experienced observer the color of the foliage in an orchard in which soil, variety, age, care and the great majority of conditions are the same, should find color of foliage as ready a test of the tree's condition as is the pulse or the temperature in animal life. Until 1910 the notes of this experiment record no differences in the color of the foliage in the different plats, but in the year named, especially after mid-season, there was a perceptibly greener tinge in the foliage of trees on plats to which nitrogen had been applied — the first difference to be counted as an effect of the fertilizers used in this experiment.

Size of leaves.—The size of the leaves must of course be a valuable index to the condition of the tree. Differences here, how-

ever, cannot be detected accurately enough by the eye; there seems to be no feasible way of obtaining the leaf area either of individual leaves or the total area; and there are objections to measuring size by taking the weight. The last method, however, is the only one that could be devised for this experiment and leaf weights were therefore taken the figures for which are set forth in Tables IX and X.

TABLE IX.—WEIGHTS OF 100 LEAVES FROM INDIVIDUAL TREES IN ORCHARD FERTILIZER EXPERIMENT.

FERTILIZER.	Row.	Tree.	Green.	Dry.	FERTILIZER.	Row.	Tree.	Green.	Dry.
Plat 1. Stable manure.	1	1	Gms. 93.2	Gms. 39.6	Plat 6. Phosphoric acid and potash.	1	11	Gms. 100.0	Gms. 47.1
	2	1	92.0	39.5		2	11	95.6	44.5
	3	1	105.8	45.0		3	11	89.5	40.9
	4	1	97.9	43.7		4	11	105.6	47.5
	5	1	74.0	32.1		5	11	82.3	37.1
	7	7	88.5	40.2		7	5	96.0	42.7
	8	7	86.9	38.7		8	5	78.5	36.8
	9	7	120.2	53.6		9	5	104.5	46.5
	10	7	103.2	46.5		10	5	83.5	36.2
	11	7	97.2	45.0		11	5	73.0	32.8
	Average...	.....	95.9	42.4		Average...	.....	90.9	41.2
Plat 2. Phosphoric acid.	1	3	85.8	39.3	Plat 4. Phosphoric acid, potash and nitrogen.	1	7	93.7	42.2
	2	3	91.4	40.8		2	7	90.3	39.5
	3	3	105.8	48.4		3	7	105.0	45.6
	4	3	104.8	47.3		4	7	94.3	43.0
	5	3	84.1	39.0		5	7	100.2	46.6
	7	9	94.0	42.9		7	1	111.4	47.0
	8	9	81.5	37.7		8	1	105.5	45.6
	9	9	77.7	34.6		9	1	86.2	37.8
	10	9	83.4	39.3		10	1	116.1	47.0
	11	9	76.1	37.0		11	1	91.9	40.2
	Average...	.....	88.5	40.6		Average...	.....	99.5	43.5
Plat 3. Check.	1	5	Gms. 76.4	Gms. 36.9	Plat 5. Check.	1	9	Gms. 82.4	Gms. 38.9
	2	5	74.9	34.8		2	9	77.5	36.3
	3	5	75.2	34.8		3	9	84.2	39.2
	4	5	83.9	38.0		4	9	87.4	40.2
	5	5	83.9	38.0		5	9	69.8	34.3
	7	5	83.9	38.2		7	3	80.6	37.0
	9	5	82.4	38.9		9	3	87.3	38.7
	10	5	77.5	36.3		10	3	82.7	37.0
	11	5	82.4	38.9		11	3	80.1	36.9
	Average...	.....	80.1	36.9		Average...	.....	80.1	36.9

TABLE X.—SUMMARY OF WEIGHTS OF 100 LEAVES IN ORCHARD FERTILIZER EXPERIMENT.

FERTILIZER.	Green.	Dry.
	Gms.	Gms.
Stable manure.....	95.9	42.4
Phosphoric acid.....	88.5	40.6
Phosphoric acid and potash.....	90.9	41.2
Phosphoric acid, potash and nitrogen.....	99.5	43.5
Check.....	80.1	36.9

Leaves from the several plats were taken for weighing as follows: Beginning at the base of the year's growth the first four were discarded because these first leaves are usually poorly developed. The next five were taken for weighing, the process being repeated twenty times from shoots well distributed about the tree, making 100 selected leaves from each tree. Within an hour after being picked the leaves were weighed, all of the work being done in the middle of the day. The leaves were then air-dried in a warm, dry room and reweighed — both weights appearing in the tables.

Here again we seem to have a measurable effect of the nitrogen. While the effect is very appreciable, it must be remembered that the leaf weights were taken only in 1910 and that weighty conclusions are not warranted. The nitrogen plats are scarcely above the average in fruit-bearing and it may be that the increase in leaf-size is due to the falling short, as compared with the maximum yields, in the fruit; or, of course it may be an initial gain for the nitrogen — a prophecy of larger gains for the coming years.

Leafing-time and blooming-time.—The time of the life events under discussion often varies a few days when plants are subjected to different treatments. Thus, in a comparison of tillage and sod-mulch made by this Station, the leafing time of the plants of tilled trees comes first and the leaves of the sod-mulched trees

drop first.¹ If the fertilizers were influencing the trees markedly differently in this experiment, it might be expected that there would be some differences in leafing-time and blooming-time. There have been none, however,—contributory evidence to the inertness of the fertilizers so far as these trees are concerned.

Annual growth of branches.—The amount of new wood a tree makes in a season is an important criterion of the response of the tree to the treatment. It measures not only present vigor but future bearing capacity. It must be remembered, however, that there is much variation in the annual growth of a tree depending upon the position of the branches. With the Rome, the difficulty is great, too, because of the much branched, twiggy habit of growth of the variety. After considering several methods of selecting the shoots for measuring and weighing, twenty annual growths were cut, distributed throughout the periphery of the head of each tree. The length and weight of these growths for each tree and each plat are shown in Tables XI and XII.

Here again we have evidence, slight though it be, that the trees on plats to which nitrogen is applied are making greatest growth. The annual growth on the trees in the stable manure plat averages for 1910 nearly an inch longer than the average for all of the trees in the experiment. If this average were for a number of years it should be counted as a most marked influence of nitrogen, but unfortunately we have data for only 1910, a serious defect in our note-taking, and in 1910 the trees in the stable manure plat, for example, bore less than an average crop of fruit for the whole experiment and it is possible, indeed probable, that these trees made a relatively large growth of wood because they were bearing a relatively small crop of fruit. So while this greater annual growth must be looked upon, together with color and weight of leaves, as proof that the nitrogen-fed trees made in 1910 greatest growth, it must be remembered that from the evidence of the diam-

¹Hedrick, U. P. A Comparison of Tillage and Sod Mulch in an Apple Orchard; *N. Y. Sta. Bul.* 314:106. 1909.

TABLE XII.—SUMMARY OF LENGTH AND WEIGHTS OF ANNUAL GROWTH IN ORCHARD FERTILIZER EXPERIMENT, 1910.

FERTILIZER.	Length.	Weight.
	<i>Inches.</i>	<i>Grams.</i>
Stable manure.....	9.5	89.8
Phosphoric acid.....	8.9	81.7
Phosphoric acid and potash.....	8.5	88.6
Phosphoric acid, potash and nitrogen.....	9.0	86.7
Check.....	8.2	74.4

eters of the trunks, such has not been the case in the past. We await with interest data to show whether this increased growth is to take place annually in the coming years.

SUMMARY OF RESULTS.

Fertilizers for apples make a very poor showing in this experiment. Thus, the growth of tree trunks, for the ten seasons fertilizers have been applied, has been the same for treated and check plats — almost conclusive evidence against the fertilizers if the whole period be considered. The yield of seven crops of fruit seems not to have been increased by the use of the fertilizers. Color, flavor, keeping quality and the like have not been influenced by the fertilizers. The favorable evidence is all furnished in 1910. The apples in the crop of this year run slightly largest on plats to which nitrogen was applied; the leaves on the plats were greenest and largest and the annual growths were largest and heaviest. Unfortunately, this data was not taken for the years previous to 1910, but it may be assumed that even the slight favorable influences shown in the characters named, if of annual occurrence, would have told in the crops and in the trunk diameters. It is fair, lacking definite evidence, to call them the initial influences of nitrogen and to await coming years to see if they be continued and if the effects in 1910 make a permanent impression on the trees. It may be that the differences should be set

down as due to some accidental circumstance. At the most they are not of sufficient magnitude as yet to warrant the conclusions that the applications of fertilizers have been materially beneficial.

The nitrogen applied is for most part lost. The potash and phosphoric acid are stored where "neither moth nor rust can corrupt." The storage, however, of these two food constituents in a soil such as ours, where there are already from three hundred to seven hundred times the quantities of them needed, is unprofitable business.

It would seem that these trees ought to respond to additions of nitrogen. For fifteen years nitrogen has been leaching from the soil and none applied artificially except in the nitrogen plats. The supply ought soon to be running low. As to potassium, phosphorus and other minerals, however, it must be remembered that an apple tree possesses a very extensive root system and a long season of growth, fitting it well to obtain the mineral constituents needed, all of which, analyses show, are abundant in this soil.

May not lime be the limiting factor in this orchard? Probably not; for calcium was plentiful in the soil at the beginning of the experiment and a superabundance of it has been added in the phosphates in four plats without appreciable effects. Besides, in a neighboring apple orchard lime was used as a fertilizer in wood ashes for twelve years without benefit. Even alfalfa in a similar soil in a nearby field did not respond to a dressing of 2,000 pounds of lime to the acre. These facts seem to rule lime out as a factor in this experiment.

The final conclusion must be that the trees in this experiment would be practically as well off in every respect had not an ounce of fertilizer been used about them. If fertilizers have no value for young apple trees in this orchard, they have no value in innumerable other orchards in New York. Fruit-growers are spending money and losing time, as we shall try to show in the next paragraphs, in "carrying coal to Newcastle." Again it must be said that the soil in this orchard is about the same as the average of the apple lands in western New York — no better, no worse. If there is any material difference, it is that this experi-

mental plantation has been better tilled and better cared for in most respects than the average orchard. But the trees have not been coddled — the care has not been better than that given in the best commercial orchards. One of the lessons the experiment should teach is that fertilizers are not necessary in some soils if tillage and good care be the rule,—the truth of the old adage “tillage is manure.”

INTERPRETATION OF RESULTS.

The facts have been given but facts signify little unless they fit into a theory. Farm and garden crops on the Station grounds respond to applications of fertilizers. Why do not apples? The answer is: 1st. There is an abundance of plant food in the soil 2d. The apple-plant is preëminently able to help itself to what is before it.

The soil contained at the beginning of this experiment and continues to contain a sufficient amount of plant food for the apple.—This soil, differing but little from average soils, is a storehouse for an enormous quantity of plant food as the following figures show. The upper twelve inches contain, as we have seen in Table II:

Nitrogen	7318 lbs. per acre.
Phosphoric acid	3240 lbs. per acre.
Potash	31015 lbs. per acre.

Van Slyke¹ of this Station made a careful study of the plant-food constituents used by bearing apple trees and found that trees thirty years old, forty feet apart, and bearing twenty bushels of apples took, in the fruit, leaves and new wood, approximately:

Nitrogen	40 lbs. per acre.
Phosphoric acid	11 lbs. per acre.
Potash	43.5 lbs. per acre.

¹ Van Slyke, L. L. *N. Y. Exp. Sta. Bul.* 265:208-210. 1905.

There was, then, at the beginning of this experiment enough nitrogen per acre to last apple trees bearing twenty bushels of fruit per tree, in round numbers, 183 years; of phosphoric acid, 295 years; of potash, 713 years. It is true that the nitrogen is in a highly soluble condition, and that there is some leaching of the other materials, but were this a commercial orchard the supply of nitrogen would probably be kept up by plowing under leguminous cover crops. The fact that the roots of the trees would obtain potash and phosphoric acid from a greater depth than twelve inches much more than offsets the probable leaching of these materials. The calculations given postulate mature trees; the trees in this experiment, since they are but coming in bearing, could not have taken nearly the amounts set down in the calculation.

We hasten to say that we are not attempting to teach that apples can be grown on this soil for 183, or 295, or 713 years without adding nitrogen, phosphoric acid or potash. These figures are given only to show the direction in which the clue may be found to explain the present inertness of fertilizers in this soil. Students of the soil now very generally argue that the capacity of a soil to grow crops does not depend upon the quantities of the food compounds present as determined by a chemical analysis, but upon the quantities of them which are available to the plants. But the soil is the seat of physical and biological interactions as well of chemical ones, and is withal so complex a medium that no one would assume to say what proportions of its nutrient components are or may be made available.

It may be safely said that the yearly plowing and thorough cultivation given this orchard have loosened, pulverized, and aerated the soil and regulated moisture, and with the addition of humus by plowing under cover crops whereby the solvent action of humus and the bacteria that thrive in soils containing humus have been secured, have made available some plant food that was unavailable at the beginning of the experiment. This, with the available food, has been quite sufficient for the trees so far.

We have no explanation to offer as to why the trees have not suffered, especially in the nitrogen plats, from over-feeding. It is a dogma of horticulture that trees are easily and harmfully over-fed by excessive quantities of nitrogen, especially in stable manure. Yet these young trees have had given to them from ten to twenty-five times the amount of this element usually recommended, and in three compounds, including stable manure, without harm. There is not much experimental evidence to show that an excess of nitrogen is harmful, but in practice, so far as animal manures at least are concerned, no one has doubted the harmful effects of large quantities.

The apple is better able than farm and garden plants to use the food of a soil.—The temptation so often arises to draw comparisons between the fertilization of orchards and of field and garden crops that it may be well to state, as the writer has done in numerous addresses and papers, the differences in the habits of growth between orchard plants and field and garden plants. Such a statement should help to show why these trees have behaved so differently on the Station grounds from herbaceous plants, which as a rule, in nearby fields, respond most markedly to nitrogen and phosphoric acid, at least.

Difference I.—Trees have a preparatory time of several seasons before fruit-bearing begins. The trees in this experiment were six years old before a crop was borne and this consisted of but a few apples. In the life of any orchard plant there are usually several "off years" in which the trees do not bear—periods of rest. Farm and truck crops make their growth, bear a crop and pass away in a single season.

Difference II.—Trees begin early in the spring and continue to grow until late fall so that fruit, leaf and wood have a relatively long period in which to develop. Annual and biennial crops, as a rule, have a much shorter season of growth and in particular their fruits are developed in a shorter time. There would seem to be less need for highly concentrated foods for the slower growing tree-plants.

Difference III.—The roots of trees run much deeper in the soil and probably spread relatively as far as those of succulent plants. The larger root-run and feeding ground should enable trees to thrive with less artificial feeding than is necessary with farm and garden crops. That trees, fruit or forest, can grow vigorously under natural conditions for a century or more, often in poor soils, is an indication of their ability to obtain nourishment from a soil upon which successive growths of most farm plants would speedily fail.

Difference IV.—Trees probably transpire larger quantities of water than herbaceous crops. There are calculations in all of the standard texts on soils showing how many tons of water are required to produce a ton of dry matter in various farm and garden crops. The drift of the figures for most of the crops upon which data can be had is to show that the more woody and fibrous the plant, the greater the number of tons of water required for a ton of dry matter. From this consideration and others, especially the relatively great number of stomata on the leaves of the apple, we are warranted in assuming that the apple is a "heavy drinker" and transpires a greater amount of water in proportion to its leaf area than do most cultivated succulent plants. If this hypothesis is correct, the nutritive soil solution may be less concentrated for the apple than for grains and vegetables and the tree be equally well fed.

Difference V.—The apple crop is about 85 per ct. water, leaving but a small percentage of solids and minerals, especially of those that it is necessary for man to supply to plants, to come from the soil. In field crops the percentage of solids taken from the soil is much larger. With the apple the leaves are left on the ground; the roughage for most part is removed from fields and gardens.

A disadvantage.—Fruit-growing differs from most other kinds of plant-growing in that it is continuous cropping of one kind, there being no opportunity to change the crop to some other which

might require different amounts of the plant-food constituents. The growing of cover crops overcomes some of the disadvantages of the single-cropping formerly and yet too often practiced in fruit-growing. In an apple-tree generation it seems certain that the nitrogen, at least, must have to be replaced.

PRACTICAL OUTCOME OF THIS EXPERIMENT.

Is it necessary to fertilize an apple orchard? This experiment indicates that in the average western New York tilled apple orchard, if well drained, well tilled and properly supplied with organic matter from stable manure or cover crops, commercial fertilizers are little needed. The exceptions will probably be found on sandy and gravelly soils deficient in potash or the phosphates and subject to droughts; or on soils of such shallowness or of such mechanical texture as to limit the root-range of apple-plants; or in soils so wet or so dry, or so devoid of humus, as to prevent proper biological activities in the soil. These exceptions mean for the most part that a soil in this region possessing the unfavorable qualities named is unfitted for apple culture — at any rate there are still thousands of acres of available fruit land in every part of the apple regions of New York that do not fall in with the exceptions. There are probably many apple orchards in New York that may be benefited by an application of one of the chief elements of fertility. Some may require two of the elements. Few, indeed, should require a complete fertilizer.

If it be true, as we surmise, from this and other experiments, that good apple lands in New York, of which there are an abundance, need little artificial fertilization if the trees are well cared for, it follows that it is folly to plant apples on the lands coming under the exceptions noted; for the cost of production is increased by the cost of the fertilizers, and, of more importance, the fertilizers may often be wasted, though the operation of the "laws of diminishing returns" under which the first application of fertilizer is most effective while each additional one pro-

duces smaller and smaller returns; and, because there is sure to be waste on poor lands where growth would be limited by other factors than fertility, as water, soil texture and the like. In other words, it is doubtful if land too poor to grow apples without fertilizers can be profitably converted into permanent good apple land, at least, by the use of the mineral manures.

How may a fruit-grower know whether his trees need fertilizers? It may be assumed at once that if trees are vigorous, bearing well and making a fair amount of new wood each season, they need no additional plant food. If the trees are not in the healthful condition described, the logical thing to do is to look to the drainage, tillage and health of the trees first and the more expensive and less certain fertilization afterward.

As a last resort, fertilizers ought not to be used to rejuvenate trees unless the owner has obtained positive evidence that his soil is lacking in some of the elements of plant food. To obtain such evidence a fruit-grower should carry on a fertilizer experiment.

PLAN FOR A FRUIT-GROWER'S FERTILIZER EXPERIMENT.

The following is a plan, adapted from this experiment, whereby a man may determine, in some measure at least, what fertilizers his orchard needs. The trees selected should be of the same variety and age and should stand in a soil as uniform in texture and fertility as the orchard affords. There should be a sufficient number of trees in each plat to offset individuality in the trees. Five trees for each plat is probably the least number that can be used with any degree of accuracy. In New York, the following fertilizers might be tried:

On Plat 1, use stable manure to supply 50 pounds of nitrogen to the acre per year. On the average, this would take about $5\frac{1}{2}$ tons of well-rotted stable manure per acre. In an orchard where the trees stand 40 feet apart, use about 400 pounds per tree.

On Plat 2, use a phosphate fertilizer in sufficient amount to supply 50 pounds of phosphoric acid per acre per year. A good recommendation is, 360 pounds of 14 per ct. guaranteed acid phosphate per acre, or 13 pounds of the fertilizer per tree.

On Plat 3, apply muriate of potash, guaranteed 48 per ct. to 52 per ct. actual potash. Apply 100 pounds of the potash per acre, which would require, of 50 per ct. actual potash, 200 pounds of the muriate of potash per acre, or 8 pounds per tree.

Combine with the potash the acid phosphate in the amounts prescribed for Plat 2.

On Plat 4, use a "complete" fertilizer, consisting of nitrogen as applied in Plat 1, and of phosphoric acid and potash as applied in Plat 3. Or, for the stable manure, substitute dried blood and nitrate of soda. The former may be had with a guaranteed analysis of from 9 per ct. to 12 per ct.; the latter contains from 15 per ct. to 16 per ct. of nitrogen. The following amounts of these two substances should be applied: 350 pounds of dried blood per acre, or 13 pounds per tree; and 100 pounds of nitrate of soda per acre, or $3\frac{2}{3}$ pounds per tree.

Plat 5 should be a check.

If thought desirable to test the influence of lime, duplicate Plat 4 with the addition of 25 pounds of slaked stone lime per tree.

The best time to apply fertilizers, all things considered, is spring, as soon as the ground can be worked. Spread broadcast about the tree over an area slightly greater than that covered by the branches of the tree. In cultivated orchards the commercial fertilizer should be harrowed in and the manure plowed under. If the results are to be at all conclusive, such an experiment should run several years. Weigh or measure the crop at harvest time to determine the relative value of the different treatments. It is not sufficient to keep count of the number of barrels of marketable fruit from each plat; culls and windfalls should be accounted for. The plats can be laid out, the materials weighed, and all plans made for such experimentation in the winter, so that the actual work in the spring need not be great.

PRUNING AND TRAINING THE GRAPE.*

F. E. GLADWIN.

To prevent overbearing and to produce fruit of high quality without sacrificing the vigor of the plants, grape vines must be pruned. This is proved by the work of Keffer in Tennessee, who found that unpruned grape vines, during the first season of neglect, gave a greater yield of fruit than pruned canes, but the average weight of the clusters was much greater on the pruned canes than on those unpruned; and the burden of fruit on the neglected vines was so great that much of the new growth died, thus greatly reducing the next crop. It is obvious, therefore, that vine growth must be restricted if we wish to produce fruit of the best size and flavor. Judicious pruning aims to accomplish this. Pruning also keeps vines within bounds, thus economizing the land and facilitating cultivation, spraying, harvesting and other vineyard practices.

In pruning grapes the relationship of the wood to fruit bearing must be thoroughly understood. The grape pruner must ever keep in mind that the fruit of any year is borne on the base of shoots of the same year, which spring from the canes of the preceding year or from older wood.

A good average yield for a Concord vine would be fifteen pounds, although certain vineyards have averaged a great deal more than this. In order to produce this amount, from forty to sixty clusters will probably be required. As each shoot bears from two to three clusters, usually two, twenty to thirty buds must be left on the previous year's growth, or sufficient spurs to furnish the required number of clusters. These buds might be left on a single cane; but usually two, three, or more canes are selected, variously distributed on one or two main stems in accordance with different well-established systems of training and trimming. Good pruning, then, means removing all wood except canes or spurs sufficient to furnish the shoots necessary for desired number of clusters.

TIME FOR PRUNING.

The time for pruning the grape varies somewhat with growers and localities, but as a rule, extends from the dropping of the leaves

* This is a reprint of Circular 16. March, 1911.

in the fall to a period just before the swelling of the buds in the spring. Some vineyardists even prune after a vigorous flow of the sap has begun, and claim that no serious injury results, but, in the opinion of the writer, such bleeding must be devitalizing. There is considerable sap flow in the vine even before weather conditions appear favorable for it, so that it is best not to delay pruning too late. In sections where grapes are not grown commercially, because of severe winters, but where they are highly prized in the home garden, it is necessary, in order to prevent freezing, to cover in position or lay on the ground for covering. To lessen the area to be covered, it is policy to prune some before so covering. In such pruning it is advisable to leave more wood than is actually needed for next year's crop, as there is danger of some of the buds being broken off or of the canes being otherwise injured by the covering and uncovering. There is an old axiom "Never prune when the wood is actually frozen." There is some foundation for such advice, as frozen canes are brittle and easily broken during handling. Other than this, there is no reason why pruning should not be done at any time during the dormant season. In the Chautauqua belt, pruning begins with the falling of the leaves and continues during the winter till just before the buds begin to swell.

HOW PRUNED.

Judicious pruning of the grape is more essential than the training to any particular system, but there does, necessarily, exist a relationship between pruning and training. Where the condition of a vine permits, it may be pruned for training to a definite system, but, in many instances, the vigor of a vine, as shown by the wood produced, will not permit of the pruning necessary to train to a desired system. Hence the subject of pruning and training becomes largely a matter of judgment with the vineyardist. He is best able to judge how much pruning each individual vine in his vineyard should receive and the system of training by which the wood can be put up to the best advantage. Where the vines are in a vigorous condition the training to be adopted becomes optional with the grower; although there is no doubt that certain varieties do best when trained to a certain type. It is generally

agreed that strong-growing varieties like Concord, Niagara and others do their best when trained according to the Drooping Type, while the weaker, slower growing ones, as Delaware, can be best trained to some form of the Upright Type, other conditions being the same. It perhaps should be stated here that the terms applied to these various types refer to the position the bearing shoots assume, rather than that of the canes. The Drooping and the Upright Type are commonly used to-day, while the Horizontal has generally been discarded.

DROOPING TYPE.—The Kniffen system and its modifications are representative of this mode of training. The growing shoots of the season are not tied, but are allowed to hang free. In this respect, the system is economical, as no summer tying is necessary, while the pendent position so places the clusters that there is less liability of sunscald.

Single-stem four-cane Kniffen system.—Plate XXI, fig. 1.—With this system a single trunk or stem is carried directly to the top wire of the trellis. With strong vines, this can be done the third year after setting, but with weak ones, a year later is better. This wire is placed at a height of five and one-half to six feet above the ground, the lower wire being from three to three and one-half feet above the ground. Two canes are taken from side spurs on the trunk at the level of each wire or just below the wire. The two upper canes are left longer, with more buds, than the two on the lower wire, as there is a tendency to produce rank, long-jointed canes if this be not done, as growth is most vigorous at the extremity of the stem. The trunk or stem is tied firmly to each wire and is kept in this position permanently. Each spring the four canes left after pruning are tied to the right and left of the stem along each wire. The pruning the following year consists in cutting out all but four canes (including those laid down last year), that have developed from the spurs or canes of the previous year, selecting those that are as close as possible to the main trunk; thus the bearing wood is renewed yearly. The spurs will lengthen rapidly, hence, it will become necessary to remove them entirely every five or six years. This can be done by selecting well placed shoots that arise from time to time from the trunk or stem.

Two-Stem Four-Cane Kniffen system.—Plate XXI, fig. 2.—This is very similar to the one just described, the only difference being that two permanent trunks are brought up from the ground, one to the height of the lower wire where two canes are taken off from spurs on one stem, and tied to the wire as before; the other stem is carried to the top wire and two canes taken from it. Some vineyardists prefer to tie the two stems together in order to make them stiffer. In using this method, the canes taken off from each stem may have the same number of buds, each stem being considered as a distinct vine.

Y-stem Kniffen system.—This differs from the above in that instead of the two stems being brought up from the ground, one is taken from the other at a distance a little below the lower wire, carried to the top wire and there tied. This makes a Y-shaped joint at this point, whence the name of this method. The number of canes laid down and the subsequent treatment are the same as in the others so far described.

Umbrella Kniffen system.—Plate XXI, fig. 3.—The chief differences between this system and the true Kniffen system are the use of two canes instead of four, and the somewhat changed position given them. Two canes of from eight to twenty buds are taken from spurs on the trunk at the top wire. These are tied to the right and left along this wire, and then bent down to the lower wire and secured. The canes are renewed yearly from spurs.

One-wire Kniffen system, Low Kniffen system.—This system is a modification of the Umbrella but differs in that the trellis has only one wire three to four feet above the ground. The single stem extends up to the wire where two canes of from ten to twelve buds are taken off and laid down to the right and left of the stem. The renewal each year, like all the others so far discussed, is from spurs. High quality of fruit and cheapness of trellis commend this system.

There are other modifications of the Drooping Type of training but for one reason or another, they have been dropped in commercial vineyards. The more common are the six or eight cane Kniffen in which three and four wires are required respectively, making an expensive trellis necessary.

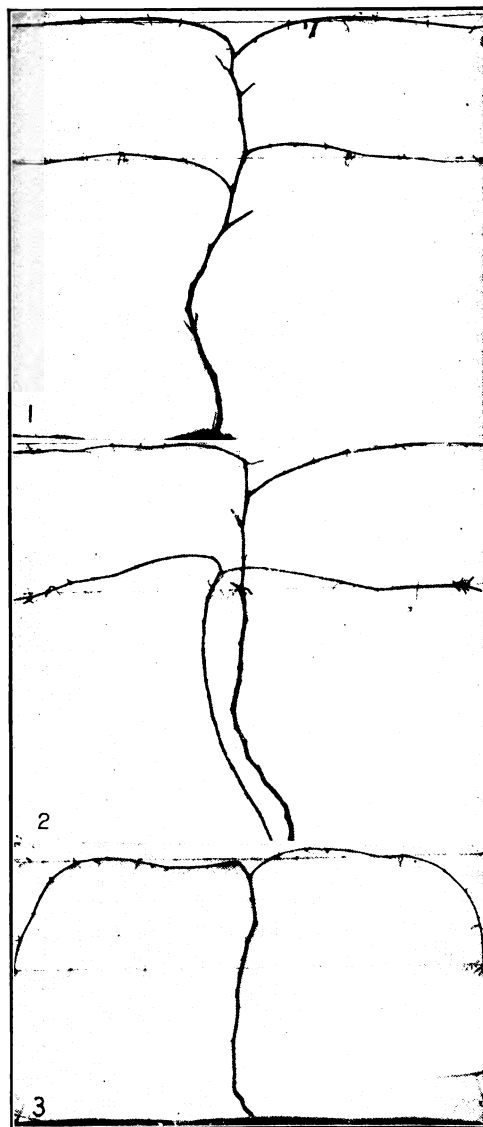


PLATE XXI.—KNIFFEN SYSTEM MODIFICATIONS: 1, SINGLE-STEM FOUR CANE; 2, TWO-STEM FOUR CANE; 3, UMBRELLA TWO CANE.

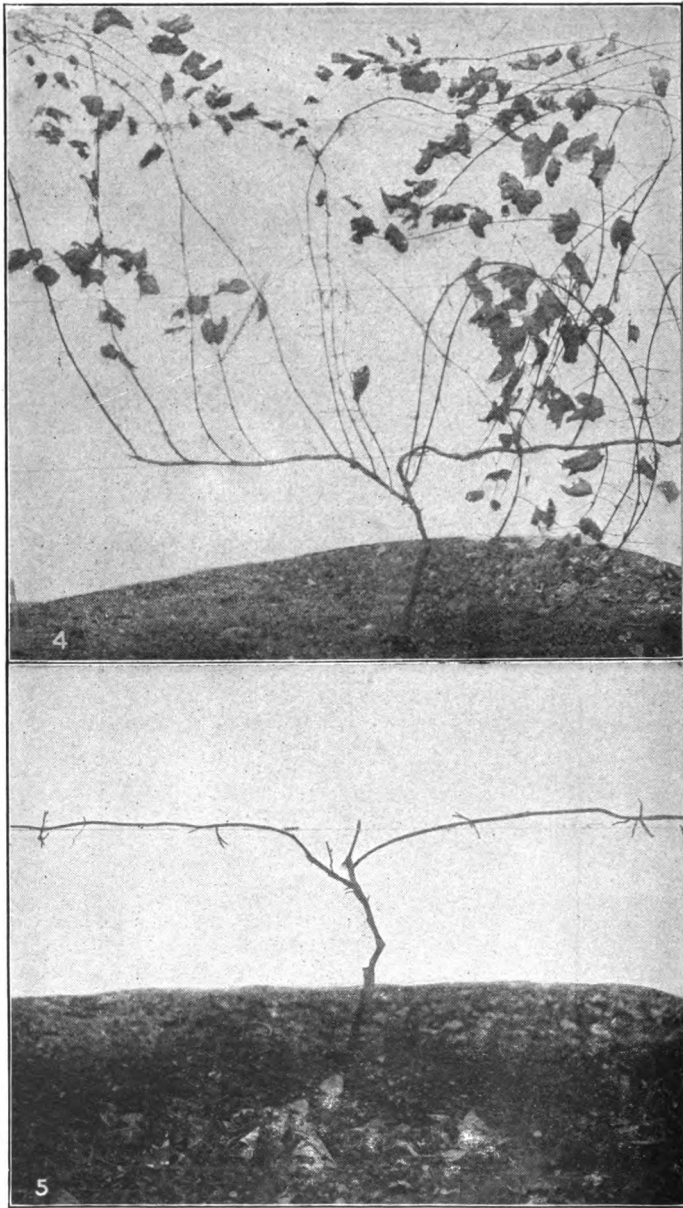


**PLATE XXII.— HIGH RENEWAL SYSTEM: 4, VINE AT END OF SEASON'S GROWTH;
5, VINE TRIMMED AND TIED.**

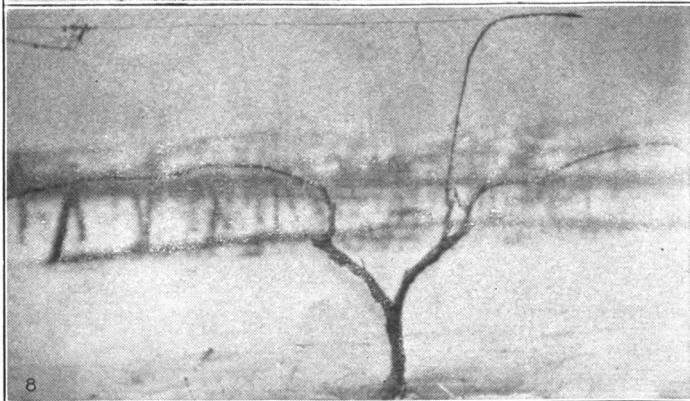
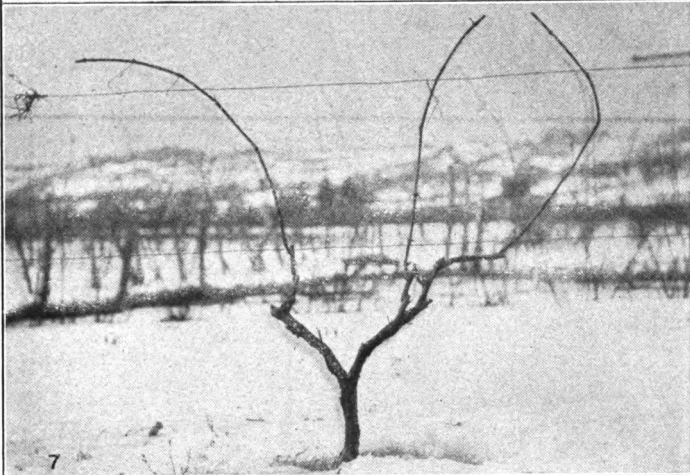


PLATE XXIII.—KEUKA LAKE SYSTEM, TEN YEAR VINE: 6. PRUNED, NOT TIED;
7, STRIPPED FOR TYING; 8, TIED.

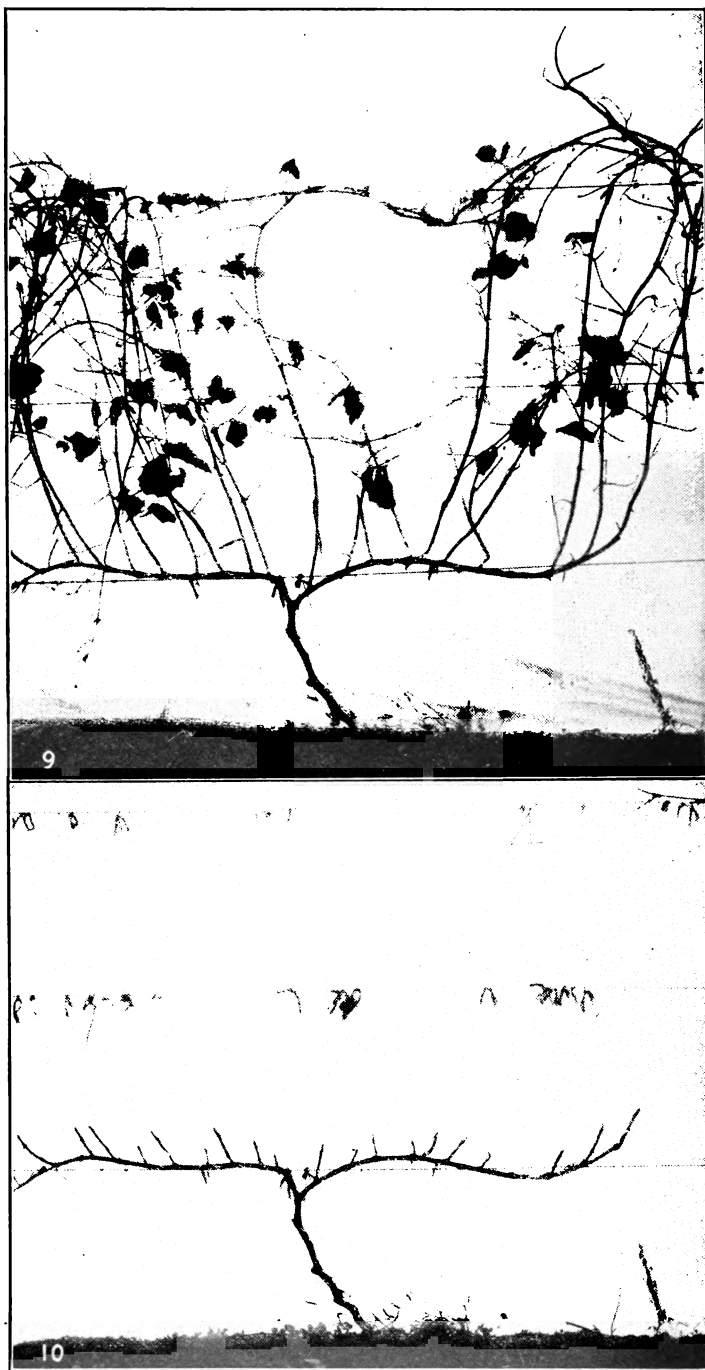


PLATE XXIV.—HORIZONTAL ARM SPUR SYSTEM: 9, AT END OF GROWING SEASON; 10, AFTER TRIMMING.

THE UPRIGHT TYPE.—This type of training carries two or more canes or arms along a horizontal wire or obliquely across the wires. The two methods of renewing in this type naturally divide into two groups, namely “High Renewal,” or “Cane Renewal,” and “Spur Renewal.”

High Renewal system.—Plate XXII.—The High Renewal system is quite generally used in many grape-growing sections, there being much to commend it. The trellis is made with two, three or more wires, usually three. The lower wire is placed from eighteen to thirty inches above the ground, while the second and third are from eighteen to twenty inches apart, respectively. The main trunk or stem of the vine is carried up to or just below the first wire and two canes, each bearing from six to ten buds, are taken off, preferably a little below the level of the wire. One is tied to the right and the other to the left. The bearing shoots that grow from the buds on these canes are tied to the second wire when they have reached a sufficient length and to the third as soon as growth will permit. When they reach above the upper wire, they may be cut off or pinched back. The beginning of the next year should see the vine again cut back to two canes that have grown from canes of the previous year or spurs, this cutting being as close to the head of the vine as possible. Near the base of each of these canes, but upon older wood at the head of the stem, short spurs carrying two or three buds are maintained, from which shoots develop and which in turn are used to furnish the fruiting canes of the following year. Thus, the spurs are the means of renewing the fruiting wood. From the above, it will be seen that the amount of old wood retained is reduced to a minimum, while the labor of tying is greatly increased.

Keuka system.—Plate XXIII.—A system of training practiced in the Keuka Lake district, and known locally as the Keuka system, appears as a modification of the High Renewal, but as there are some differences a description is warranted.

The first year after setting, the vines are allowed to grow at random on the ground. At the beginning of the second year they are pruned back to two buds. If the vine is a strong grower it is tied this season to the lower wire of the trellis, which is from

eighteen to twenty inches above the ground. The beginning of the third year finds the vines cut back to a stem or trunk ten to twenty inches high, tied to the lower wire. The fourth year the vine consists of the short stem and two or three canes, each of five to eight buds, laid along the lower wire and tied. The shoots from these are carried perpendicularly to the second and third wires which are about twenty inches apart, as fast as growth will permit. The following year all the wood is cut away except two or three canes that have grown from the buds nearest the head of the trunk. These canes are of from five to eight buds. The number retained after each pruning depends upon the variety and vigor of the vine. If two canes are left they are tied to the right and left along the lower wire; if three, the third is carried to the second wire and then tied along it. As there is a tendency for long spurs to result from the repeated renewals secured in this manner, frequently buds from the head of the stem are allowed to develop and fruiting wood secured from them. Thus the fruiting wood arises from near the head of the trunk, and as this is usually short almost the entire vine is renewed annually. When the trunk approaches the end of its usefulness a shoot is allowed to grow from the ground and this eventually becomes the trunk, the old one being cut away. The advantages claimed for this method of training are the low head, the reduction of the old wood to a minimum and the ease of getting a complete renewal.

Spur Renewal; Horizontal Arm Spur System.—Plate XXIV. — The trellis for this system is practically the same as for the High Renewal. Two canes are laid down, one to the right, and the other to the left of the trunk, which has been brought to the height of the lower wire or just below. The number of buds left on each cane will depend upon the vigor of the vine and the availability of the space between the adjoining vines. These canes are to become permanent arms, doing service for several years. The shoots that develop from buds on these canes the present year are cut back to two buds in the fall or winter. Two shoots are allowed to grow from each of these spurs and tied to the upper wires. In the fall the cane developed from the upper bud of the spur is cut entirely away, and the other cane cut to two buds as before. Then

at the beginning of the next season, we have as in the previous year, two shoots springing from a spur on a permanent arm. The spurs will lengthen fast and become crooked, hence it is the best practice to cut them away entirely every few years and grow others from shoots that arise from the arms. The spurs may be distributed from five to twenty inches apart on the arms.

Spur Renewal; Chautauqua system.—This system is but a modification of the Horizontal Arm Spur system just described. Permanent arms are used to support the canes, which are tied yearly to a two- or three-wire trellis. These canes may be tied obliquely or perpendicularly. If two wires are used, they are usually thirty-four inches apart, if three, about twenty inches apart. The canes for tying up the following year either develop directly from the old wood of the arms, from spurs on the arms, or from the base buds of the past season's canes. This system has a strong hold upon the vineyardists of Chautauqua county, as the principal grape, the Concord, adapts itself fairly well to training according to this system. The old arms should be renewed at frequent intervals in order to use this system to the best advantage, as in time they become crooked, gnarled and the extremities often a great distance from the head of the vine.

Fan system.—While still used in certain localities, this method of training is not nearly so popular as it was a few years since. Here the renewals are made yearly from spurs near the ground, retaining very little old wood. One serious objection of the system is the tendency of the spurs to be lengthened, becoming crooked and reaching in some instances to midway between the first and second wires. The shoots are tied to the wires in the direction that they naturally assume; this may be vertically, horizontally or obliquely across the wire. In regions where grapes are grown for home use and the climate necessitates winter protection, this system is used to advantage.

HORIZONTAL TYPE.—This type is little used at present as the cost of the trellis and the labor of tying render it prohibitive. One cane arising from a trunk one to two feet high is left after each pruning. This is carried perpendicularly to the top wire and the shoots arising therefrom are tied to slats or wires extend-

ing vertically from the lower to the upper wire of the trellis. The one advantage of the system is the ease of control for varieties that are likely to overbear or are already weakened and require careful nursing to bring them back.

The choice of a system of training is largely a matter of taste with the vineyardist. One type may be suited for his conditions or at least may appeal to him as the ideal one. Select the system that is best suited for the variety to be grown; and here a knowledge of varietal habits is indispensable. In commercial vineyards the expense of trellis, of pruning and tying becomes an important factor. Any system to have merit must be so adaptable to the variety or the individual vine, that it will conserve the best energies of the vine from year to year, and *vice versa* any system that permits of overbearing one year at the sacrifice of vine energy and wood for the succeeding year should be remodeled or dropped altogether.

THE TRELLIS.

Chestnut or locust posts are preferred for the trellis. These should be from six to eight feet in length, the heaviest of which should be selected for end posts. After sharpening to a tapering point they can be driven into holes made with a crowbar. Care should be taken to place them so that they will line perfectly on the side toward the prevailing wind, on which side the wire is fastened. A post to every three vines is sufficient. The end posts should be driven to a depth of 22 to 24 inches and braced by a 2 x 4 or 4 x 4, notched to fit the post half way from the ground to the top and extending obliquely to the ground where it is held by a 4 x 4 stake. The wire should be No. 9 or No. 10, the number and height of wires depending upon the vigor of the vines and the system of training used. The wires are fastened to the posts by ordinary fence staples, enough space being left in the staple to permit loosening or tightening. The wire is secured to the end post by winding it once around the post and then around itself.

GRAFTING AND PROPAGATING PLANTS.*

W. H. ALDERMAN.

GRAFTAGE.

The first task in all grafting work is the selection of the cion. This should be taken from one-year-old wood although it is possible to use two and even three-year-old wood with some degree of success. Always secure a strong and well-matured growth, discarding all soft and pithy sticks as worthless. The time to cut cion wood is while the buds are absolutely dormant. The cions may be packed in damp moss or similar material and stored in a cool cellar until the buds break in the trees to be grafted. Care should be taken not to have the moss too wet or the cions will become water-soaked and worthless. In making up the cions at grafting time the first few inches of the year's growth should be discarded, inasmuch as the buds are small, poorly developed, often abortive, and will not start readily. The tips of the cion sticks should also be discarded as the buds are frequently immature and the wood too soft.

Cleft graft.—The cleft graft is pre-eminent in work on large trees and can be used successfully on branches ranging from one to six inches in diameter, although those about an inch and a half to two inches across are the most convenient and satisfactory. The limb should be sawed off squarely, and carefully split with the grafting chisel and mallet. (Pl. XXVIII, figs. 4 & 10.) In making the split care should be taken to see that it does not run into a knot but extends straight down on either side of the limb. In extreme cases where four or more cions are wanted, the extra clefts should be made parallel to the first and not across it. With the two halves of the limb spread apart by means of the wedge on the grafting chisel, we are ready to prepare the cions. These should contain two or three buds, preferably three. Beginning on either side of a bud, with two strokes of the knife, cut the lower end of the cion in the form of a wedge, one side of which should be slightly narrower than the other. (Pl. XXV, figs. 1 & 2.) The

* A reprint of Circular 17. March 15, 1911.

wedge of the cion is then inserted into the cleft with its narrower side toward the center of the stock, thus allowing the outer and thicker edge of the cion to be firmly gripped when the stock springs back against it. The utmost care should be taken to match the growing layer, or inner bark, of the cion with that of the stock or to see that they come in contact in one or more places. It is well for the beginner to set the cion at a slight angle in order to insure the crossing of the two layers. (Pl. XXV, fig. 3.)

The final step is the waxing¹ of the graft. The wax should be heated in warm water until it will work readily and then spread in a thin coat over all the cut surfaces including the tips of the cions and extended down the limb on both sides covering the entire length of the cleft. (Pl. XXV, fig. 4.) If this covering of wax is not air-tight the cion will die.

Whip graft.—The whip graft, used on nursery stock and small limbs, is easily made and because of the several uniting edges is very apt to form a good union. The stock ought to be cut off just above a smooth place so that no knots or shoulders will interfere with the work and a section should be cut diagonally from one side an inch and one-half to two inches in length. About half an inch from the end of the stock cut, but do not split, a tongue about half an inch long. (Pl. XXVI, fig. 1.) The objection to splitting the tongue is that it leaves a rough surface which will not fit tightly to the cion. The base of the cion is prepared in the same way as the stock except that the first diagonal cut extends clear across the stick. (Pl. XXVI, fig. 2.) The two are then fitted firmly together, care being taken to match the growing parts along one side. The union should be wound with common twine or, if

¹ A good general purpose grafting wax may be made from the following formula:

Resin	4 lbs.
Beeswax	2 lbs.
Tallow	1 lb.

Melt all three ingredients together, cool somewhat and pour into cold water. Grease the hands well and as soon as the wax becomes cool enough to handle, pull and work it until it assumes a light brownish-yellow color. It may then be moulded into balls of convenient size and stored in a cool place until ready for use. If a softer wax is desired substitute linseed oil for a part or all of the tallow.

available, waxed string,¹ and then thoroughly waxed. (Pl. XXVI, fig. 5.) After growth is well started, usually in June, the strings under the wax should be cut to prevent girdling. This may be done by drawing a sharp knife up the back side of the graft.

The whip, or tongue, graft is used almost universally in root grafting. (Pl. XXVI, fig. 6.) The roots of apple seedlings are cut into pieces about four or five inches long and cions are prepared of the same length. The process is the same as in top-working except that no wax is used, the grafts being packed away in damp moss in sand in a cool cellar until spring when they are planted in nursery rows, leaving only the upper bud above ground. Sometimes a whole root is used instead of the short pieces.

Bridge graft.—This too seldom used but extremely valuable form of grafting differs in purpose from the two just described. Although having to do with preservation rather than propagation, it would seem that because of its great importance in horticulture it should be described somewhat in detail here. Its most important use is to preserve trees injured or girdled by rodents or disease. Any ragged or diseased edges should be cleanly cut away, a longitudinal slit should be made in the bark, both above and below the wound, and the edges of the slits loosened slightly. A cion should then be cut two or three inches longer than the space to be bridged, one side beveled off at both ends (Pl. XXV, fig. 5), and inserted in the slits, its beveled face against the wood of the trunk. (Pl. XXV, fig. 6.) In order to guard against any accidental displacement it would be well to drive a small tack or nail through each end of the cion, which, however, must not be split in the operation. Other cions in a like manner may be inserted at intervals of about two inches over the entire injured surface. (Pl. XXV, fig. 6.) The ends of the cions should be covered with wax (Pl. XXV, fig. 7) but it is not necessary to cover all the bridged portion of the trunk. If the tree operated upon is small and likely to weave in the wind it should be tied firmly to a strong stake as such movements might tear apart the tender uniting surfaces.

¹ Waxed string may be made by running a willow twig through a ball of No. 16 cotton twine and immersing the twine in nearly boiling wax for three minutes. When taken out to cool the ball should be slowly turned over several times by means of the twig to prevent the hot wax from settling on the lower side.

BUDDING.

The fruit-grower has not practiced budding to any extent as a top-working method, although it lends itself very readily to such work. Its main drawback is that under the raised edges of the bark around the inserted bud, the budmoth finds a comfortable hibernating place and will frequently destroy the tender tissue as it starts into growth in the spring. This may be avoided by a careful inspection of the trees two or three times a week during May and early June.

Budding is performed during the summer after mature buds are formed on the current season's growth. The bud-sticks are not cut until nearly ready for use and then the leaves are trimmed away at once leaving about a quarter of an inch of the stem as a handle to the bud. (Pl. XXVII, fig. 2.) After trimming, the sticks are wrapped in damp burlap and are taken to the field for use; once they become dried they are worthless. As in grafting, the buds at the end of the year's growth are discarded, the plump, hard buds near the middle being the most vigorous.

At the point where the bud is to be inserted a T shaped incision is made (Pl. XXVII, fig. 3), the transverse cut being secured by a rocking motion of the knife and the vertical one by lightly drawing the knife upward from a point about an inch below the first cut. Before removing the knife a slight twist of the blade will loosen the edges to better receive the bud. Here the advantage of the straight pointed knife (Pl. XVII, fig. 2) over the curved form at one time in general use is at once apparent, for the latter could not be twisted to open the bark without boring into and injuring the tender tissue beneath. The bud is cut from below upward with a drawing motion of the knife. It is well to cut nearly the entire thickness of the bark at the point of the bud so that it will not crumple up when inserted into the stock. Almost no wood is cut away with the bud unless just under the "eye" but on the other hand the bud must not be cut so thin that the soft growing tissue between the bark and wood is injured or destroyed. (Pl. XXVII, fig. 1.) In some plants such as the quince one may leave a thin strip of wood the entire length of the bud, while with roses it is customary to remove all the wood by making the first upward cut very deep and merely severing the bark by a cross cut above the bud. By grasping the bud firmly between the thumb and fore-

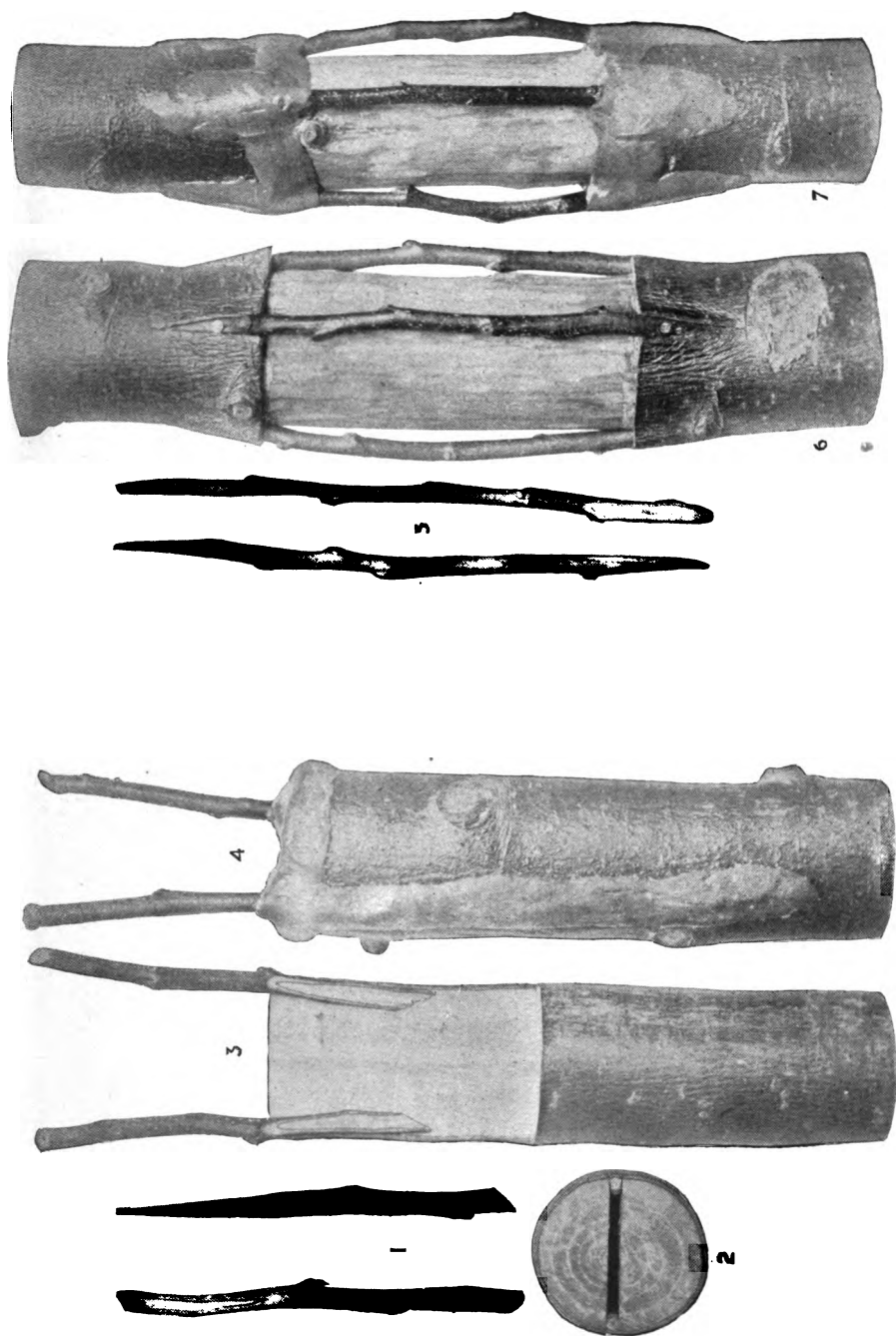


PLATE XXV.—CLEFT AND BRIDGE GRAFTING.

1, Cions prepared for cleft grafting; 2, cross-section with cions in place; 3, cions properly placed and secured; 4, completed, waxed cleft graft; 5, cions prepared for bridge grafting; 6, cions properly placed and secured; 7, completed, waxed bridge graft.

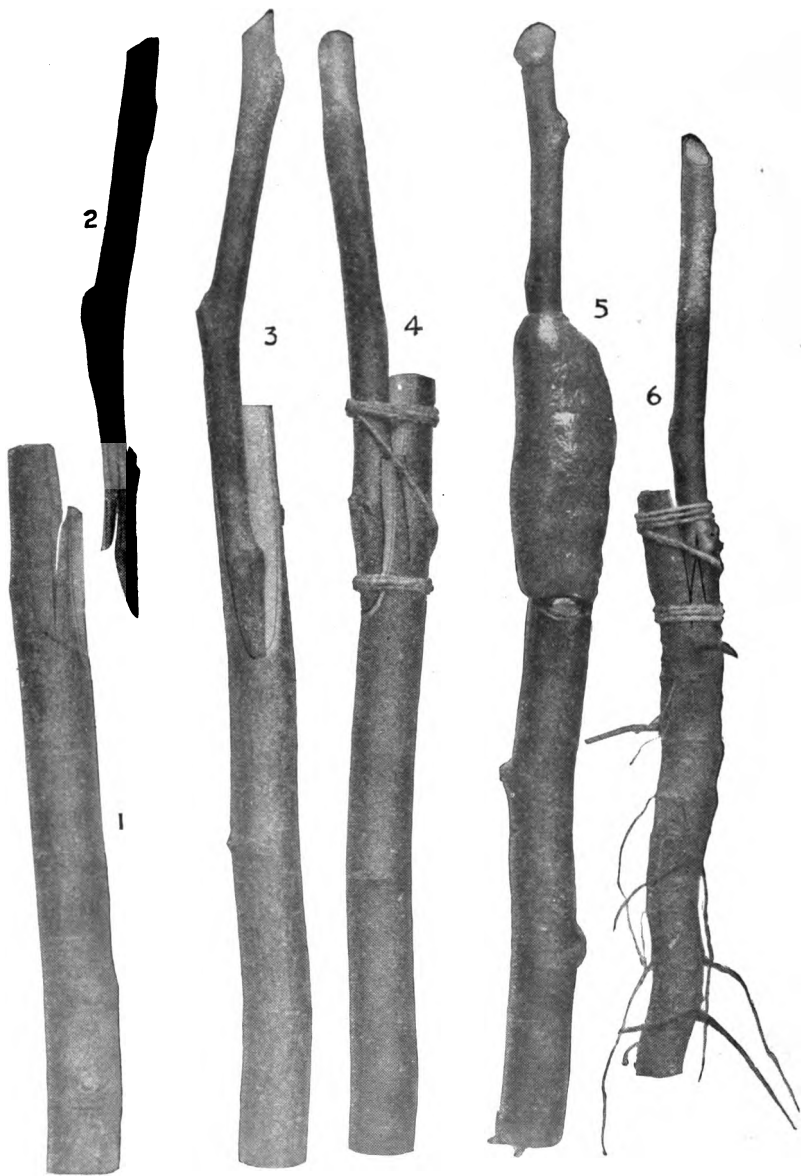


PLATE XXVI.—WHIP, OR TONGUE, GRAFTING.

1, Stock prepared; 2, cion prepared; 3, parts properly placed; 4, parts secured by waxed twine; 5, completed, waxed whip graft; 6, whip graft on root.

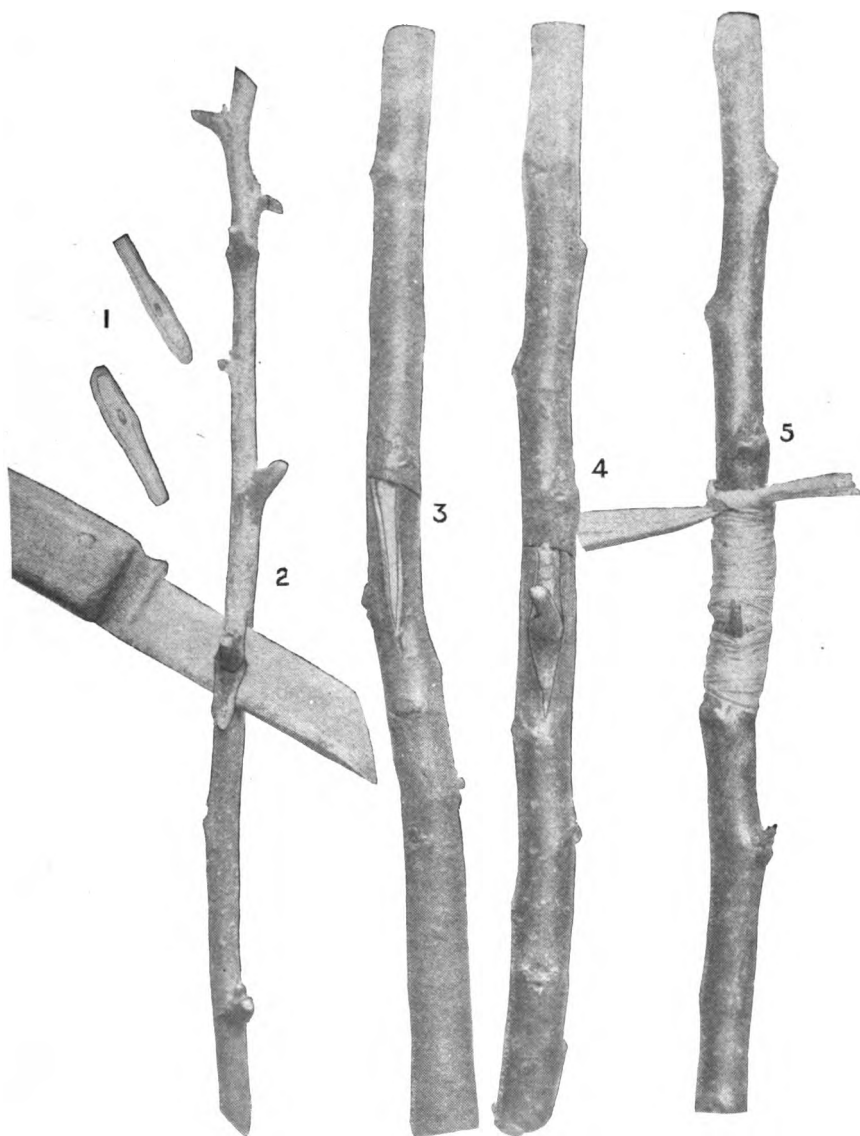


PLATE XXVII.—BUDDING.

1, Wood side of cut buds; 2, cutting bud from bud stick; 3, stock ready for bud; 4, bud properly placed; 5, bud tied with raffia.

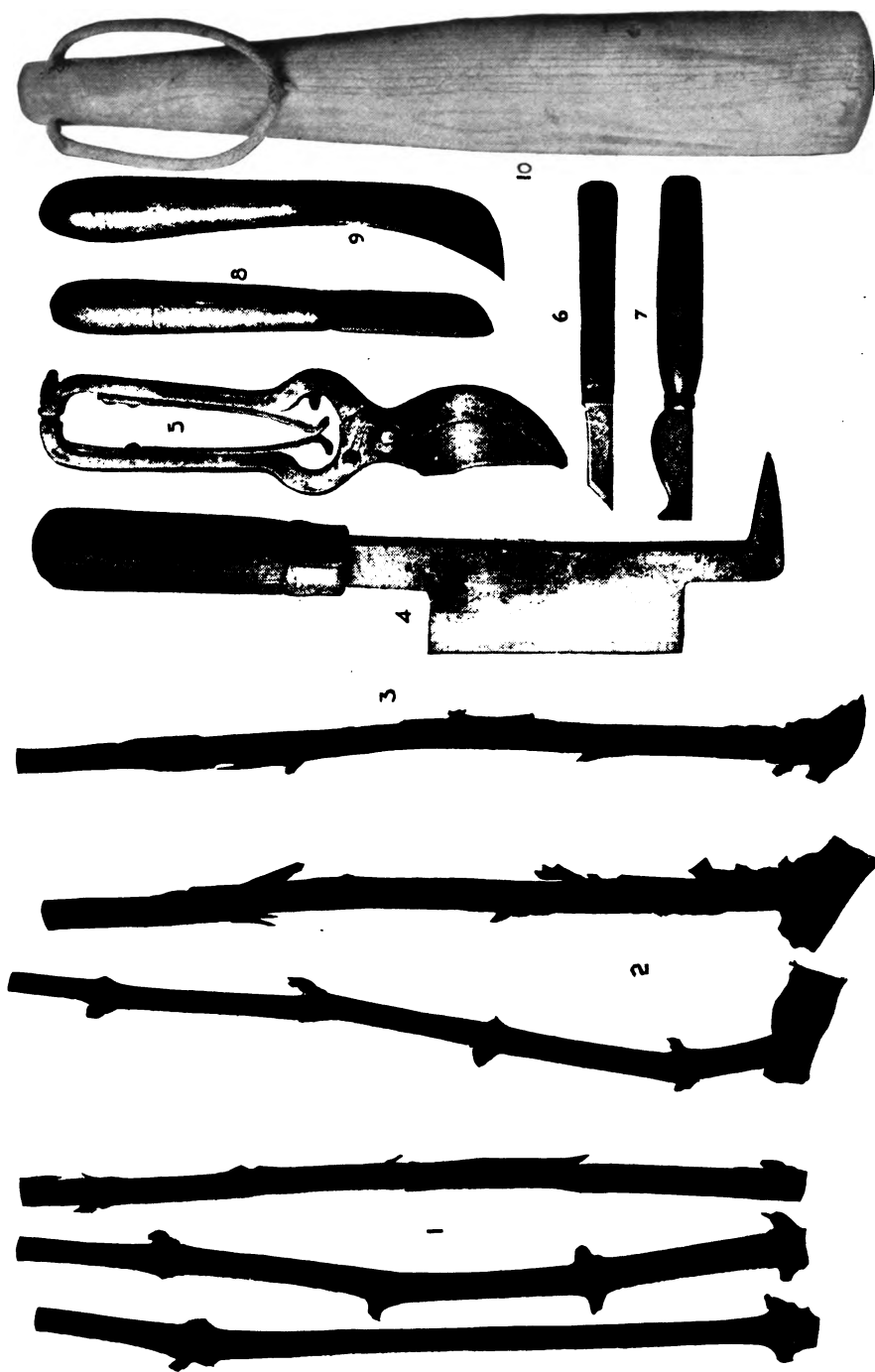


PLATE XXVIII.—CUTTINGS; AND GRAFTING, BUDDING AND PRUNING TOOLS.

1, Straight cuttings; 2, mallet cuttings; 3, heel cutting; 4, grafting chisel; 5, pruning shears; 6, budding knife; 7, string-cutting knife; 8, grafting knife; 9, pruning knife; 10, grafting mallet.

finger it can then be readily lifted free from the wood. With the leaf stem as a handle the bud may be inserted into the T shaped incision and pushed down until its "heel" is flush with the transverse cut. (Pl. XXVII, fig. 4.)

No waxing is necessary but the bud must be securely tied. For this purpose raffia is now almost universally used. It is cut up into lengths of eighteen or twenty inches and moistened to make it more soft and pliable. The strand is first brought firmly across the upper end of the bud to keep it from working out. Beginning then at the bottom of the slit the raffia is wound smoothly upward covering everything but the "eye" itself and is tied in a single square knot. (Pl. XXVII, fig. 5.) It is essential that this winding be tight, for it must hold the bud immovably in place and be practically air-tight. In from two to four weeks, depending on the growth of the stock, the raffia should be cut to prevent girdling of the tree. The bud by this time should be well set but should not put forth any growth, merely lying dormant until the following spring, when the stock is cut away just above the bud.

Stocks.—In connection with budding the question of stocks upon which fruit trees are worked naturally presents itself. Of such stocks there are many. The apple may be grown as a dwarf upon Paradise; as a semi-dwarf upon Doucin, or as a standard upon French Crab or American-grown seedlings. The French seedlings are preferable to our domestic stock because they make a more uniform growth and are generally somewhat more vigorous. The pear is dwarfed by being budded upon the Angiers quince and is grown on French seedlings as a standard. Cherries are grown both upon Mazzard and Mahaleb stocks. The Mazzard is the more difficult to bud and does not grow as well in the nursery but it produces an orchard plant far superior to that of the Mahaleb. Cherry growers, in New York at least, would do well to insist that their trees be worked upon Mazzard stock. Plums in this State are almost entirely budded upon Myrobalan stock but it is generally supposed that this has a tendency to dwarf the tree. It would probably be better to use the Saint Julien for the common *Domestica* varieties, at least, although this is more difficult to bud than the Myrobalan. Quinces were formerly propagated by cuttage and layerage almost entirely but are now frequently budded upon Angiers stock. No one seems to know definitely

which system produces the best orchard plants although popular sentiment seems to favor the former. In growing peach trees one should use the southern pits exclusively. Canning-factory seeds frequently germinate poorly, the seedlings are not uniform in growth and there is danger that they may be infected by Yellows.

He who contemplates propagating trees can usually buy the desired stock from any one of several large importing concerns. He should buy first class stock which ought to measure at the collar from one-fourth to seven-sixteenths of an inch in diameter. The roots should be pruned to a uniform size and shape to facilitate planting and the tops cut back to twelve or fourteen inches. They are then stored in a cellar with the roots packed in damp sand or moss until spring when they are put out in nursery rows four feet apart and about eight inches in the row. In planting care should be taken to pack the earth firmly about the roots. These seedlings are budded during the ensuing summer and the following spring are cut off just above the inserted bud, which should receive the full strength of the plant.

In growing peaches somewhat different methods are followed. Pits are secured from the south in early September, and, in order to crack the shells, are stratified in sand. This consists of simply covering layers of pits with layers of sand and thoroughly wetting the pile several times during the fall. After the bed thaws out in the spring the meats which have been freed by the process may be picked out and kept in a cool place until planting time. When the ground has been thoroughly prepared they may be planted in rows much the same as corn or beans. In growing peaches and all nursery stock it should be borne in mind that success depends directly upon care and that frequent and thorough cultivation is a prime requisite. It is important that the soil be plowed up to the young trees in the fall to guard against injury by mice and to leave the ground in a loosened condition for work in the spring.

Inasmuch as the various kinds of trees used as stocks for budding vary greatly in length of their growing season, it naturally follows that the time during which they may be budded will vary accordingly. During a normal season these periods will be about as indicated in the table, although the dates may have to be made a little earlier or later if the season be unusually dry or wet.

PROPER TIME TO BUD VARIOUS STOCKS.

Rose	July 1 — July 10
Pear	July 10 — July 15
Apple	July 15 — Aug. 1
Plum (St. Julien Stock)	July 15 — Aug. 1
Plum (Myrobalan Stock)	Aug. 15 — Sept. 1
Cherry (Mazzard Stock)	July 20 — Aug. 1
Cherry (Mahaleb Stock)	Aug. 20 — Sept. 1
Quince	July 25 — Aug. 15
Peach	Aug. 20 — Sept. 10

CUTTAGE.

Cuttings may be made from roots, underground rootstalks, soft growing tissue and from hard wood, but the average fruit-grower is concerned mostly with the latter. Hardwood cuttings should be made in the fall from the mature wood of the current season's growth, and are usually from six to ten inches in length. The lower cut is made close to a bud (Pl. XXVIII, fig. 1) because roots strike most readily at the joints; the upper one somewhat removed from the joint to prevent undue drying out of the last bud. (Pl. XXVIII, fig. 1.) These cuttings are then made up into bundles with the butts together and are buried upside down in sand. By this arrangement the butts receive the heat from the late fall and early spring sun and form a callus over the cut surfaces. Roots will spring more readily from a calloused cutting than from an uncalloused one. Cuttings may also be made up during the early winter and be buried in sand in a cellar but as a rule they do not callous well by this method. The heel and mallet cuttings (Pl. XXVIII, figs. 3 and 2) are variations of the common type and should be treated in the same manner. The currant matures its wood early and cuttings may be made from it the last of August or the first of September, in which case the cuttings will become calloused after being buried six or eight weeks and may be transferred to the nursery row at once. They should be well mulched during the winter to prevent heaving and undue freezing of the wood.

Cuttings are usually planted deep enough so that the upper bud is flush with the level of the ground. Where propagation by this method is extensive a furrow may be plowed, the cuttings placed upright against the land side from two to four inches apart and the earth firmly pressed around them. Many grape propagators insist that the cuttings be inserted at an angle claim-

ing that they get a far better strike in this way. This may be accounted for by the fact that the soil can be packed more firmly and the heat from the sun's rays can penetrate more readily to the lower ends of the cuttings and force them into growth.

LAYERAGE.

Layerage differs from cuttage in that the roots and stems of the offspring individuals are formed while still connected with the parent plant and may be successfully employed in propagating varieties that do not strike readily from cuttings. The most common method of layering plants is to bend over a branch and cover the tip with earth. After this takes root the stem may be severed and we have a separate individual. The black raspberry is universally propagated in this manner. Where the branch is long and viny as in the grape a whole vine may be laid upon the ground and buried or it may be covered only in certain places. Roots will start at intervals and by severing the vine between them new plants are formed. A third method called Mound Layering or Stooling is practiced with the quince, gooseberry, Paradise apple and others. The plants are cut back in the spring close to the ground to stimulate a strong growth of shoots. The following fall or spring these are mounded up with earth sufficiently high to cover several of the lower buds. If the shoots make a strong growth the mounding may be made during early summer of the year they are cut back. Roots will strike from the joints or nodes and by autumn the soil may be taken away, the stems severed below the roots and the plants set out in the nursery row or stored until spring. After removing the rooted plants the old stools may be covered with soil or a heavy mulch to prevent drying or freezing back of the stubs. In the spring this covering should be removed, new shoots will spring forth and the whole operation may be repeated.

These are only a few of the most common and most practical methods of plant propagation applicable to fruit growing. To suit various conditions and individual fancies these methods may be varied in an almost infinite variety of ways to discuss which at this time would be both tedious and without purpose.

INSPECTION WORK.

REPORT OF ANALYSES OF SAMPLES OF FERTILIZERS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1911.*

(The analyses reported in these Bulletins cease to have value long before they could be reprinted in this Report; and are, therefore, omitted.— W. H. JORDAN, *Director*.)

INSPECTION OF FEEDING STUFFS.†

(See note above.— W. H. JORDAN, *Director*.)

* Printed as Bulletin No. 340.

† Printed as Bulletin No. 341.

APPENDIX.

I. PERIODICALS RECEIVED BY THE STATION.

II. METEOROLOGICAL RECORDS.

PERIODICALS RECEIVED BY THE STATION.

Acclimation	Complimentary
Agricultural Epitomist	Complimentary
Agricultural Gazette of New South Wales.....	Complimentary
Agricultural Journal and Mining Records (Natal).....	Complimentary
Agricultural Journal of the Cape of Good Hope.....	Complimentary
Agricultural Ledger	Complimentary
Agricultural News	Complimentary
Allegan Gazette	Complimentary
American Agriculturist	Subscription
American Breeders' Magazine.....	Subscription
American Chemical Journal	Subscription
American Chemical Society, Journal.....	Subscription
American Cultivator	Complimentary
American Entomological Society, Transactions.....	Subscription
American Fertilizer	Subscription
American Florist	Subscription
American Grocer	Complimentary
American Hay, Flour and Feed Journal.....	Complimentary
American Journal of Physiology.....	Subscription
American Miller	Complimentary
American Naturalist	Subscription
American Philosophical Society, Proceedings.....	Complimentary
American Poultry Advocate.....	Complimentary
American Poultry World.....	Subscription
American Stock Keeper	Complimentary
American Sugar Industry and Beet Sugar Gazette.....	Complimentary
Analyst	Subscription
Annales de l'Institut Pasteur.....	Subscription
Annales de la Societe Entomologique de Belgique.....	Complimentary
Annals Mycologici	Subscription
Annals and Magazine of Natural History.....	Subscription
Annals of Botany.....	Subscription
Archiv der Gesammte Physiologie (Pflueger).....	Subscription
Archiv fuer Hygiene.....	Subscription
Association Belge des Chimistes, Bulletin.....	Complimentary
Beet Sugar Gazette.....	Complimentary
Berichte der deutschen botanischen Gesellschaft.....	Subscription
Berichte der deutschen chemischen Gesellschaft.....	Subscription
Better Fruit	Complimentary
Biedermann's Zentralblatt fuer Agrikultur Chemie.....	Subscription
Biochemische Zeitschrift	Subscription
Biochemisches Centralblatt	Subscription
Biological Bulletin	Subscription

Biologisches Centralblatt	Subscription
Blooded Stock	Complimentary
Boletim de Agricultura.....	Complimentary
Boletim do Instituto Agronomico.....	Complimentary
Boletin de la Sociedad Nacional de Agricultura.....	Complimentary
Boletin de Ministerio de Frumento.....	Complimentary
Botanical Gazette	Subscription
Botanische Zeitung	Subscription
Botaniste, Le	Subscription
Buffalo Society of Natural Sciences, Bulletin.....	Complimentary
Bulletin de l'Institut Pasteur.....	Subscription
Bulletin of the Department of Agriculture, Jamaica.....	Complimentary
Caledonia Era	Complimentary
California Cultivator	Complimentary
California Fruit Grower	Subscription
California University Publications—Botany.....	Complimentary
Canadian Entomologist	Subscription
Canadian Horticulturist	Complimentary
Centralblatt fuer Bakteriologie, etc.....	Subscription
Chemical Abstracts.....	Subscription
Chemical Society, Journal.....	Subscription
Chemisches Centralblatt	Subscription
Chicago Daily Farmers' and Drovers' Journal.....	Complimentary
Chicago Dairy Produce.....	Complimentary
Cincinnati Society of Natural History, Journal.....	Complimentary
Cold Storage and Ice Trades Review.....	Complimentary
Colman's Rural World.....	Complimentary
Colonial Dairy Produce Report.....	Complimentary
Columbus Horticultural Society Journal.....	Complimentary
Commercial Poultry	Complimentary
Connecticut Farmer	Complimentary
Country Gentleman	Subscription
Country Life in America.....	Subscription
Country World	Complimentary
Criador Paulista	Complimentary
Dairy and Produce Review.....	Complimentary
Elgin Dairy Report.....	Complimentary
Elisha Mitchell Scientific Society, Journal.....	Complimentary
Entomological News	Subscription
Entomological Society of America, Annals.....	Subscription
Entomological Society of Washington, Proceedings.....	Subscription
Entomologische Zeitschrift	Subscription
Entomologist	Subscription
Entomologists' Record	Subscription
Farm and Fireside.....	Complimentary
Farm and Live Stock Journal.....	Complimentary
Farm and Orchard.....	Complimentary

Farm and Stock.....	Complimentary
Farm Economies	Complimentary
Farm Journal	Complimentary
Farm Life	Complimentary
Farm News	Complimentary
Farm Poultry	Complimentary
Farm, Stock and Home.....	Complimentary
Farm Stock Success.....	Complimentary
Farmers' Advocate	Complimentary
Farmers' Call	Complimentary
Farmers' Guide	Complimentary
Farmers' Voice	Complimentary
Feathered World	Subscription
Florists' Exchange	Subscription
Flour and Feed.....	Complimentary
Flour Trade News.....	Complimentary
Fruit Grower	Complimentary
Fruitman and Gardener.....	Complimentary
Garden	Subscription
Garden Magazine	Subscription
Gardeners' Chronicle	Subscription
Gardeners' Chronicle of America.....	Complimentary
Gardening	Subscription
Gartenwelt	Subscription
Gas and Oil Power	Complimentary
Gleanings in Bee Culture.....	Complimentary
Grape Belt, The.....	Complimentary
Green's Fruit Grower	Complimentary
Hartwick Seminary Monthly	Complimentary
Hawaiian Forester and Agriculturist.....	Complimentary
Hedwigia	Subscription
Herd Register	Complimentary
Hoard's Dairyman	Complimentary
Holstein-Friesian Register	Complimentary
Holstein-Friesian World	Complimentary
Homestead	Complimentary
Hygienische Rundschau	Subscription
Indiana Farmer.....	Complimentary
Insect World (Japanese)	Complimentary
Ithaca Chronicle	Complimentary
Jahresbericht der Agrikultur-Chemie	Subscription
Jahresbericht Garungs-Organismen	Subscription
Jahresbericht der Nahrungs- und Genussmittel.....	Subscription
Jahresbericht Pflanzenkrankheiten	Subscription
Jahresbericht der Tier-Chemie	Subscription
Jahresheft Schlesische Insektenkunde.....	Complimentary
Jersey Bulletin	Complimentary

Journal of Agricultural Science	Subscription
Journal of Agriculture, Victoria.....	Complimentary
Journal of Biological Chemistry	Subscription
Journal of Board of Agriculture (English).....	Complimentary
Journal de Botanique.....	Subscription
Journal of the College of Agriculture, Tokyo.....	Complimentary
Journal of the Dept. of Agriculture of Western Australia....	Complimentary
Journal of the New Zealand Department of Agriculture.....	Complimentary
Journal of Economic Biology.....	Subscription
Journal of Experimental Medicine	Subscription
Journal of Experimental Zoology	Subscription
Journal of Industrial and Engineering Chemistry.....	Subscription
Journal fuer Landwirtschaft	Subscription
Journal of Physiology	Subscription
Just's Botanischer Jahresbericht	Subscription
Kimball's Dairy Farmer	Complimentary
Königlichen Bayerische Akademie der Wissenschaften: Sitzungsberichte der Math.—Phys. Classe.....	Subscription
Land, The	Complimentary
Landwirtschaft-Historische Blätter	Complimentary
Landwirtschaftlicher Jahrbucher	Subscription
Landwirtschaftlicher Jahrbuch der Schweiz	Subscription
Landwirtschaftlichen Versuchs-Stationen	Subscription
Live Stock and Dairy Journal	Complimentary
Live Stock Report	Complimentary
Long Island Democrat	Complimentary
Market Fruit-Growers' Journal	Complimentary
Marlboro Record	Complimentary
Memoirs of the Department of Agriculture in India.....	Complimentary
Metropolitan and Rural Home	Complimentary
Michigan Farmer	Complimentary
Milchwirtschaftliches Zentralblatt	Subscription
Minnesota and Dakota Farmer	Complimentary
Mirror and Farmer	Complimentary
Modern Farming	Complimentary
Monthly Bulletin of the N. Y. State Department of Health...	Complimentary
Monthly Weather Review	Complimentary
Mycologia	Subscription
National Nurseryman	Complimentary
National Farmer and Stock Grower	Complimentary
National Stockman and Farmer	Complimentary
Naturaliste Canadienne	Complimentary
Nebraska Farmer	Complimentary
New Education	Complimentary
New England Farmer	Complimentary
New York Academy of Science, Annals and Transactions....	Subscription

New York Botanical Garden, Bulletin	Complimentary
New York Entomological Society, Journal	Subscription
New York Farmer	Complimentary
New York Fruit and Produce News	Complimentary
New Zealand Dairyman	Complimentary
North American Horticulturist	Complimentary
Northwest Pacific Farmer	Complimentary
Nut Grower	Complimentary
Ohio Farmer	Complimentary
Ohio Naturalist	Subscription
Oklahoma Farm Journal	Complimentary
Pacific Coast Fanciers' Monthly	Subscription
Pacific Northwest	Complimentary
Pacific Fruit World	Complimentary
Pennsylvania Farmer	Complimentary
Photo-Miniature	Subscription
Parasitology	Subscription
Popular Agriculturist	Complimentary
Poultry	Complimentary
Poultry Herald	Subscription
Poultry Husbandry	Complimentary
Poultry Item	Complimentary
Poultry Industry	Complimentary
Poultry Keeper	Complimentary
Poultry Monthly	Complimentary
Power and Engineer	Subscription
Practical Dairyman	Complimentary
Practical Farmer	Complimentary
Practical Fruit Grower	Complimentary
Praktische Blaetter fuer Pflanzenschutz.....	Subscription
Progressive Farmer	Complimentary
Profitable Farming	Complimentary
Psyche	Subscription
Rabenhorst's Kryptogamen-Flora	Subscription
Reliable Poultry Journal	Subscription
Republic	Complimentary
Revue Generale de Botanique	Subscription
Revue Generale du Lait	Subscription
Revue Horticole	Subscription
Revue Mycologique	Subscription
Royal Agricultural Society, Journal.....	Subscription
Royal Horticultural Society, Journal.....	Subscription
Rural Life	Complimentary
Rural New Yorker	Subscription
Salt Lake Herald	Complimentary
Saint Louis Academy of Science, Transactions.....	Complimentary

Sanitary Inspector	Complimentary
Science	Subscription
~~Scientific American~~	~~Subscription~~
Scientific Roll, Bacteria	~~Subscription~~
Skaneateles Democrat	Complimentary
Smallholder, The	Complimentary
Society of Chemical Industry, Journal	Subscription
Societe Entomologique Belgique, Annales	Complimentary
Societe Entomologique de France, Bulletin	Complimentary
Societe Mycologique de France, Bulletin	Subscription
Southeast Missouri Farm, Fruit and Poultry	Complimentary
Southern Planter	Complimentary
Southern Tobacconist and Modern Farmer	Complimentary
Southern Farm Magazine	Complimentary
Southwestern Farmer and American Horticulturist	Complimentary
Southwestern Farmer and Breeder	Complimentary
Stallion and Jack News	Complimentary
Standard and Poultry World	Complimentary
Station, Farm and Dairy	Complimentary
Stazione Sperimentale Agrarie Italiane	Complimentary
Student Farmer, The	Complimentary
Successful Farming	Complimentary
Suffolk Herald	Complimentary
Sugar Beet	Complimentary
Texas Stockman and Farmer	Complimentary
Torrey Botanical Club, Bulletins and Memoirs	Subscription
Transvaal Agricultural Journal	Complimentary
Trucker and Farmer	Complimentary
Up-to-Date Farming and Gardening	Complimentary
Utica Semi-Weekly Press	Complimentary
Wallace's Farmer	Complimentary
Weekly Enquirer (Cincinnati)	Complimentary
West Indian Bulletin	Complimentary
West Virginia Farm Review	Complimentary
Western Fruit-Grower	Complimentary
Western Plowman	Complimentary
Zeitschrift fuer Analytische Chemie	Subscription
Zeitschrift fuer Biologie	Subscription
Zeitschrift fuer Entomologie	Complimentary
Zeitschrift fuer Hygiene und Infektionskrankheiten	Subscription
Zeitschrift fuer Pflanzkrankheiten	Subscription
Zeitschrift fuer Physiologische Chemie	Subscription
Zeitschrift fuer Untersuchung der Nahrungs und Genussmittel	Subscription
Zentralblatt fuer Biochemie und Biophysik	Subscription
Zoological Record	Subscription
Zoologischer Anzeiger	Subscription

METEOROLOGICAL RECORDS FOR 1911.

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METEOROLOGICAL RECORDS FOR 1911.
READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1911.

DATE.	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.....	37.	21.	23.	9.	35.	18.	31.	21.	76.	58.	69.	52.
2.....	47.	35.	43.	16.	33.	25.	30.	24.	71.	34.	73.	59.
3.....	45.	21.	32.	8.	36.	21.	35.	18.	42.	28.	79.	58.
4.....	21.	37.	37.	27.	32.	14.	38.	22.	34.	27.	77.	45.
5.....	18.	-1.	33.	12.5	28.	7.	62.	33.	63.	30.	77.	51.
6.....	28.	6.	17.	6.	27.	21.	70.	42.	72.	36.	74.	57.
7.....	35.	21.	29.	16.	30.	1.	67.	36.	75.	39.	73.	59.
8.....	40.5	24.	33.	23.	41.	18.	45.	27.	80.	41.	79.	59.
9.....	40.	21.	38.	24.	44.	23.	46.	28.	76.	47.	83.	53.
10.....	35.	11.	34.	19.	42.	33.	51.	32.	77.	52.	88.	60.
11.....	43.	30.	43.	20.	43.	22.	55.	26.	91.	46.	86.5	64.
12.....	33.	19.	37.	23.	43.	36.	58.	34.	87.	43.	86.	63.
13.....	38.	20.	34.	30.	46.	28.	62.	37.	87.	41.	76.	58.
14.....	38.	26.	36.	22.	49.	26.	59.	47.	72.	55.	70.	55.
15.....	35.	23.	29.	21.	50.	27.	58.	34.	85.	57.	70.	49.
16.....	23.	6.	38.	15.	27.	-1.	47.	28.	79.	49.	74.	46.
17.....	52.	7.	52.	32.	34.	11.	41.	28.	85.	51.	83.	48.
18.....	28.	0.	45.	37.	37.	29.	57.	28.	84.	58.	87.	54.
19.....	34.	16.	34.	16.	37.	22.5	65.	39.	86.	64.	87.	65.
20.....	34.	24.	42.	20.	44.	29.	57.	40.	95.	61.	76.	50.
21.....	45.	28.	20.	11.	44.	30.	52.	34.	95.	63.	76.	50.
22.....	28.	4.	30.	4.	62.	32.	40.	33.	92.	66.	77.	62.
23.....	32.	17.	32.	11.	38.	18.	46.	33.	92.	61.	78.	49.
24.....	44.	14.	34.	25.	43.	12.	62.	33.	73.	53.	81.	62.
25.....	46.	18.	51.	25.	49.	10.	74.	35.	80.	50.	85.	63.
26.....	39.	33.	49.	31.	57.	33.	77.	42.	87.	54.	89.	68.
27.....	48.	37.	45.	25.	60.	38.	77.	46.	93.	60.	87.	64.
28.....	47.	34.	25.	14.	38.	46.	80.	39.	90.	74.	74.	49.
29.....	43.	26.	.....	.....	33.	22.	80.	53.	81.	58.	82.	49.
30.....	48.	17.	.....	.....	36.	25.	74.	.....	82.	54.	.....	.....
31.....	22.	10.	.....	.....	34.	23.	.....	.....	82.	54.	.....	.....
Monthly averages.....	36.4	19.4	34.4	18.8	40.	21.9	55.9	33.8	79.3	50.5	79.1	55.9

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1911 — (Concluded).

DATE.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.	5 P. M.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1.....	93.5	55.	91.	64.	82.	58.	55.	42.	51.	31.	42.	29.
2.....	100.5	72.	90.	69.	87.	57.	58.	45.	34.	26.	36.	31.
3.....	103.	72.	83.	69.	85.	59.	59.	33.	46.	25.	32.	21.
4.....	104.	71.	83.	69.	75.	49.	78.	34.	51.	27.	23.	18.
5.....	105.	68.	88.	67.	32.	49.	66.	34.	49.	32.	45.	33.
6.....	98.	74.	87.	69.	74.	62.	48.	41.	47.	30.	53.	29.
7.....	86.	68.	93.5	64.	70.	54.	52.	38.	54.	43.	59.	29.
8.....	83.	57.	94.5	71.	65.	54.	62.	34.	47.	38.	33.	53.
9.....	102.5	70.	85.	61.	76.	57.	68.	38.	51.	35.	67.	38.
10.....	101.	72.	93.	60.5	80.	56.	70.	40.	59.	42.	64.	41.
11.....	98.	64.	85.	66.	80.	60.	63.	53.	68.	41.	58.	49.
12.....	85.	71.	79.	52.	77.	60.	66.	53.	61.	31.	57.	42.
13.....	82.	59.	84.	52.	61.	42.	59.	34.	32.	18.	42.	32.
14.....	86.	54.	91.	54.	63.	35.	65.	34.	33.	20.	37.	25.
15.....	85.	58.	85.	55.	68.	53.	63.	30.	36.	25.	43.	33.
16.....	92.	61.	86.	66.	81.	57.	70.5	42.	34.	24.	43.	33.
17.....	76.	61.	85.	65.	77.	56.	65.	46.	34.	22.	45.5	26.
18.....	81.	55.	83.	59.	77.	54.	61.	46.	39.	27.	28.	21.
19.....	83.	53.	72.	53.	73.	54.	61.	46.	35.	28.	30.	14.
20.....	82.5	63.5	77.	52.	72.	52.	67.	47.	35.	28.	36.	19.
21.....	85.	51.	82.	49.	73.	45.	66.	55.	22.	26.	40.	33.
22.....	77.	51.	89.	49.	73.	45.	63.	54.	35.	22.	36.	33.
23.....	83.	55.	85.	63.	77.	42.	60.	41.	40.	21.	44.	33.
24.....	82.	58.	88.	55.	84.	65.	64.	41.	35.	20.	46.	32.
25.....	73.	50.	85.	55.	78.	61.	51.	34.	35.	20.	49.	30.
26.....	77.	50.	77.	61.	68.	49.	53.	38.	41.	29.	42.	30.
27.....	80.	50.	85.	59.	69.	40.	45.	36.	47.	30.	30.	15.
28.....	86.	58.	84.	66.	69.	40.	49.	26.	54.	39.	29.	15.
29.....	85.	67.	85.	58.	61.	39.	53.	27.	54.	23.	23.	13.
30.....	85.	67.	85.	58.	61.	39.	53.	27.	54.	23.	23.	13.
31.....	89.	60.	84.	49.	58.	41.	57.	43.	35.	25.	38.	20.
Monthly averages.....	88.2	60.7	82.2	59.6	73.8	51.8	60.4	41.	44.2	28.9	41.5	28.6

READINGS OF THE STANDARD AIR THERMOMETER.

DATE.	JANUARY.			FEBRUARY.			MARCH.			APRIL.			MAY.			JUNE.		
	7 A. M.		5 P. M.	7 A. M.		12 M.	7 A. M.		12 M.	7 A. M.		12 M.	7 A. M.		12 M.	7 A. M.		12 M.
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1.....	30.	35.	36.	11.	22.	23.	21.	30.	33.	25.	28.	25.	63.5	65.	71.	55.	57.	69.
2.....	40.	46.	42.	35.	42.	16.	26.	32.	28.	23.	27.	27.	36.	37.	36.	62.	71.	77.
3.....	25.	23.	21.	10.	33.	31.	22.	32.	29.	27.	34.	33.	31.	37.	41.	62.	71.	77.
4.....	10.	13.	8.	17.	33.	33.	9.	30.	23.	33.	38.	34.	40.	51.	52.	63.	75.	74.
5.....	16.	11.	10.	16.	18.	13.	26.	26.	25.	41.	53.	57.	45.	59.	61.	58.	66.	64.
6.....	22.	28.	23.	8.	8.	17.	26.	23.	21.	43.	57.	67.	51.	69.	70.	54.	59.	62.
7.....	23.	29.	26.	24.	28.	26.	10.	26.	30.	36.	41.	40.	51.	73.	74.	59.	70.	70.
8.....	35.	38.5	40.	30.	33.	30.	29.	36.	36.	32.	40.	40.	60.	75.	75.	63.	73.	76.
9.....	26.	25.	21.	25.	35.	34.	37.	40.	42.	31.	49.	48.	57.	76.	70.	71.	82.	84.
10.....	12.	30.	31.	42.	29.	29.	37.	37.	39.	39.	50.	53.	68.	86.	88.	73.	88.	87.
11.....	40.	41.	42.	20.	33.	36.	33.	43.	40.	39.	49.	54.	69.	88.	80.	80.	80.	83.
12.....	27.	36.	30.	31.	34.	34.	31.	42.	47.	51.	59.	58.	46.	69.	77.	67.	70.	70.
13.....	31.	38.	33.	23.	26.	26.	31.	48.	57.	61.	63.	68.	51.	78.	79.	63.	63.	65.
14.....	26.	26.	23.	23.	26.	25.	35.	43.	57.	61.	63.	68.	59.	89.	82.	69.	69.	69.
15.....	9.	10.	11.	24.	36.	35.	31.	48.	57.	61.	63.	68.	59.	89.	82.	69.	69.	69.
16.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
17.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
18.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
19.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
20.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
21.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
22.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
23.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
24.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
25.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
26.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
27.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
28.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
29.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
30.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
31.....	2.	21.	22.	39.	36.	35.	18.	32.	32.	32.	43.	43.	56.	88.	82.	67.	81.	81.
Monthly averages.....	25.3	29.9	27.8	23.9	28.9	28.1	27.3	35.1	33.7	39.7	50.2	50.8	59.3	73.1	72.3	65.	73.4	73.6

READINGS OF THE STANDARD AIR THERMOMETER — (Concluded).

DATE.	JULY.			AUGUST.			SEPTEMBER.			OCTOBER.			NOVEMBER.			DECEMBER.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1.....	69.	85.	92.	74.	87.	89.	62.	77.	80.	48.	48.	49.	37.	36.	31.	34.	38.	36.
2.....	81.	96.	98.	74.	81.	73.	65.	82.	84.	47.	52.	53.	31.	31.	30.	34.	36.	31.
3.....	83.	99.	102.	71.5	80.	79.	61.	74.	71.	38.	57.	55.	33.	40.	39.	26.	26.	32.
4.....	86.	100.	100.5	72.	82.	86.	60.	71.	60.	72.	66.	66.	33.	44.	42.	16.	22.	37.
5.....	82.	99.	89.	72.	81.	81.	66.	70.	64.	46.	48.	48.	36.	46.	41.	32.	40.	31.
6.....	81.	95.	84.	73.	81.	81.	67.	70.	62.	43.	48.	41.	39.	44.	47.	35.	48.	41.
7.....	75.	83.	89.	73.	87.	83.	57.	61.	59.	44.	49.	46.	51.	50.	46.	31.	49.	46.
8.....	71.	83.	89.	68.	87.	84.	53.	58.	59.	44.	58.	56.	40.	43.	40.	37.5	49.	42.
9.....	81.	93.	101.	68.	88.	84.	62.	70.	77.	44.	64.	60.	37.	46.	45.	45.	52.	51.
10.....	85.	99.	91.	69.	88.	84.	62.	70.	77.	44.	64.	60.	37.	46.	45.	45.	52.	51.
11.....	80.	93.	73.	71.	98.	87.	63.	77.	77.	54.	54.	56.	45.	51.	56.	41.	57.	56.
12.....	73.	82.	79.	62.	78.	75.	64.	64.	61.	54.	51.	59.	45.	55.	51.	52.	56.	56.
13.....	68.	78.	76.	69.	81.	77.	43.	54.	52.	40.	53.	45.	40.	44.	33.	34.	37.	34.
14.....	67.	82.	81.	65.	77.	76.	45.	58.	60.	37.	57.	57.	30.	31.	33.	27.	36.	37.
15.....	69.	84.	78.	67.	77.	80.	46.	56.	53.	34.	59.	50.	34.	34.	34.	40.	41.	39.
16.....	70.	85.	70.	67.	74.	80.	46.	56.	53.	34.	59.	50.	34.	34.	34.	40.	41.	39.
17.....	62.	75.	69.	67.	71.	79.	39.	73.	73.	54.	58.	54.	38.	38.	30.	35.	38.	42.
18.....	60.	73.	66.	66.	70.	82.	38.	73.	73.	54.	58.	54.	38.	38.	30.	35.	38.	42.
19.....	68.	78.	73.	69.	77.	70.	38.	73.	73.	54.	58.	54.	38.	38.	30.	35.	38.	42.
20.....	66.	76.	70.	67.	77.	70.	38.	73.	73.	54.	58.	54.	38.	38.	30.	35.	38.	42.
21.....	61.	71.	77.	61.	70.	80.	35.	66.	66.	57.	64.	60.	32.	32.	32.	36.	36.	36.
22.....	63.	73.	72.	66.	85.	80.	37.	68.	70.	57.	63.	60.	32.	32.	32.	36.	36.	36.
23.....	68.	76.	73.	68.	85.	80.	37.	68.	70.	57.	63.	60.	32.	32.	32.	36.	36.	36.
24.....	70.	78.	73.	68.	85.	80.	37.	68.	70.	57.	63.	60.	32.	32.	32.	36.	36.	36.
25.....	67.	75.	65.	65.	80.	68.	35.	73.	74.	45.	53.	50.	30.	38.	40.	36.	40.	35.
26.....	61.	71.	65.	59.	62.	62.	38.	73.	78.	44.	53.	51.	31.	31.	30.	34.	34.	34.
27.....	61.	71.	70.	62.	73.	78.	40.	69.	69.	38.	53.	51.	31.	31.	30.	34.	34.	34.
28.....	61.	75.	70.	66.	80.	76.	47.	54.	54.	40.	46.	46.	36.	40.	36.	36.	36.	36.
29.....	61.	75.	80.	72.	72.	72.	47.	54.	54.	40.	46.	46.	36.	40.	36.	36.	36.	36.
30.....	68.	85.	84.	59.	62.	60.	45.	57.	52.	34.	50.	48.	34.	30.	27.	26.	26.	23.
31.....	71.5	81.	88.	54.	64.	62.	45.	54.	55.	41.	49.	48.	29.	34.	32.	32.	32.	37.5
Monthly averages.....	70.6	83.4	81.7	66.	76.4	75.9	57.2	68.1	67.4	45.5	55.8	53.4	34.	39.2	36.8	32.7	37.5	35.4

SUMMARY OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS FOR 1911.

	Maximum.	Minimum.	STANDARD.		
			7 A. M.	12 M.	5 P. M.
	Average.	Average.	Average.	Average.	Average.
January.....	36.4	19.4	25.3	29.9	27.8
February.....	34.4	18.8	23.9	28.9	28.1
March.....	40	21.9	27.3	35.1	33.7
April.....	55.9	33.8	39.7	50.2	50.8
May.....	79.3	59.5	59.3	73.1	72.6
June.....	79.1	55.9	65	73.4	73.6
July.....	88.2	60.7	70.6	83.4	81.7
August.....	82.2	59.6	66	76.4	75.9
September.....	73.8	51.8	57.2	68.1	67.4
October.....	60.4	41	45.5	55.8	53.4
November.....	44.2	28.9	34	39.2	36.8
December.....	41.5	28.6	32.7	37.5	35.4

MONTHLY MAXIMUM AND MINIMUM TEMPERATURE FROM 1883 TO 1911, INCLUSIVE.
(Highest and Lowest Record for each Month in Bold Face Type.)

	JANUARY.				FEBRUARY.				MARCH.			
	Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883.....	18.	44.	11.	-9.	17.	48.	24.	-2.	19.	61.	9.	2.
1884.....	3.	49.	26.	-13.	7.	55.	29.	-3.	30.	54.	1.	-4.
1885.....	1.	61.	29.	-6.	10.	38.	11.	11.5	28.	48.	13.	-11.
1886.....	5.	52.5	13.	-18.7	9.	50.	27.	-1.	16.	58.	1&5	-2.5
1887.....	24.	50.7	19.	-8.	9.	54.2	27.	-4	28.	51.7	1&5	8.7
1888.....	12.	43.2	23.	-6.	21.	49.	10.	-7.	28.	57.	30.	0.
1889.....	18.	55.	20.	5.	23.	42.	4 & 24	-9.5	13.	61.8	8.	18.5
1890.....	6.	67.	29.	9.	5.	64.5	11 & 21	2.5	12.	62.	2.	4.5
1891.....	3.	46.	17.	-4.	26.	56.8	18.	2.8	27.	52.2	6.	9.
1892.....	3.	48.	10.	-6.	15.	44.	6.	-1.	24.	54.	26.	15.
1893.....	29.	46.	11.	-6.	20.	47.6	27.	-8.5	25.	52.	5 & 16	12.
1894.....	7.	45.	18.	-11.	14.	46.	8.	-21.	31.	56.5	2.	6.
1895†.....	30.	53.	26.	-16.5	29.	48.5	1 & 27	5.5	21.	63.	2.	17.5
1896.....	13.	57.	30 & 31	-3.5	18.	56.5	2 & 3	-8.	13.	63.	2.	13.
1897.....	13.	50.	12.	-4.	22.	52.5	1.	-8.	13.	63.	2.	13.
1898.....	13.	50.	30 & 31	-4.	22.	52.5	1.	-8.	13.	63.	2.	13.
1899.....	23.	58.	12.	-2.	14.	36.	24.	-2.5	24.	67.5	8.	14.
1900.....	16.	48.	21.	-2.	26.	52.	18.	-3.	12.	78.5	19.	10.
1901.....	3.	48.	28.	-2.	28.	62.5	6.	-18.	19.	78.5	14 & 2	18.
1902.....	3.	48.	28.	-2.	28.	62.5	6.	-18.	19.	78.5	14 & 2	18.
1903.....	23.	48.	19.	-12.	20.	63.	5 & 14	-6.	27.	81.	5.	1.
1904.....	23.	48.	19.	-12.	20.	63.	5 & 14	-6.	27.	81.	5.	1.
1905.....	1.	71.	26.	-3.	20.	63.	5 & 14	-6.	27.	81.	5.	1.
1906.....	21.	53.	24.	-18.	15.	53.	12 & 18	-14.	28.	73.	1.	8.
1907.....	6.	45.	31.	-9.	15.	53.	5.	-14.	28.	73.	1.	8.
1908.....	22.	45.	19.	-7.	15.	53.	5.	-14.	28.	73.	1.	8.
1909.....	24.	64.	10.	-8.	16.	40.	7.	-3.	24.	82.	14 & 18	17.
1910.....	2 & 23	45.	5.	-1.	17.	52.	22.	-4.	24.	82.	14 & 18	17.
1911.....	27 & 30	48.	5.	-1.	17.	52.	22.	-4.	24.	82.	14 & 18	17.

* Maximum for first eleven days only. Record incomplete. † From data given by Mr. Edgar Parker. Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURE FROM 1883 TO 1911, INCLUSIVE — (Continued).
(Highest and Lowest Record for each Month in Bold Face Type.)

	APRIL				MAY				JUNE			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883												
1884	16.	75.	1.	19.	11.	87.	1 & 14	31.	7.	83.5	2.	42.
1885	28.	74.5	10.	23.	24.	88.7	3.	32.5	25.	80.5	13.	41.
1886	24.	84.5	4.	20.5	28.	80.7	17 & 18	37.5	14.	86.5	23.	41.5
1887	11.	80.7	8.	22.2	23.	78.5	1.	37.5	17.	83.2	1.	42.2
1888	20.	82.5	8.	16.	18.	88.2	3.	37.5	22.	89.2	15.	47.7
1889	20.	84.5	1.	26.	13.	79.8	29.	37.	23.	81.1	4.	40.
1890	13.	78.8	1 & 19	23.	18.	91.8	2.	30.	22.	82.6	5.	46.
1891	28.	81.4	7.	25.5	11.	80.7	4.	39.5	30.	83.6	8.	44.8
1892	13.	75.3	26.	25.5	31.	78.8	9.	32.2	16.	82.	6.	40.
1893	21.	71.3	2.	28.	25.	88.	14.	35.5	14.	92.	11.	45.8
1894	30.	80.	3.	20.	2.	85.4	13 & 21	40.	21.	91.6	6.	38.
1895*	17.	87.	4 & 5	19.	31.	87.5	7 & 20	32.6	21.	96.	7.	53.
1896	26.	82.	20.	19.	11.	80.	8.	32.5	24 & 25	89.	3.	43.
1897	14 & 18	69.	5.	18.	24.	79.	6.	34.	9.	87.5	2.	42.
1898	30.	82.	3.	23.	2.	87.5	15.	32.5	6 & 24	90.	16.	40.
1899	30.	82.	9.	†22.	2.	88.5	7.	27.	25	93.	11.	41.5
1900	28.	78.	12.	28.	15 & 16	88.5	16.	36.	27	95.5	2.	45.
1901					23.	78.			28	95.5		
1902	22.	87.	5.	25.	22.	90.	11.	26.	3	85.	6.	38.
1903	30.	86.	5.	21.	19.	89.	2.	30.	30.	86.5	1.	39.
1904	24.	67.5	14.	16.	25.	88.	12.	31.5	5, 24	89.	12 & 17	45.
1905	27 & 28	75.	16.	23.	3.	82.	2.	29.5	4 & 25	90.	1.	40.
1906	19.	74.	2.	25.	24.	88.5	11 & 21	30.	19.	92.	12.	37.
1907	29.	73.	2.	19.	14.	85.	2 & 11	28.	8.	92.	3.	41.
1908	29.	78.	4.	18.	29.	90.	1, 4 & 5	31.	18.	94.	12.	43.
1909	19.	75.	11.	12.	31.	78.	2 & 3	33.	28.	92.	8.	43.
1910	4.	84.	7.	27.	20.	79.	16.	31.5	22.	89.9	4.	36.
1911	29.	80.	3.	18.	22.	97.	4.	27.	11.	90.5	17.	46.

* From data given by Mr. Edgar Parker. Station record not available. † Thermometers broken. Record not taken from April 19 to 24, inclusive.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURE FROM 1883 TO 1911, INCLUSIVE — (Continued).
(Highest and Lowest Record for each Month in Bold Face Type.)

	JULY.				AUGUST.				SEPTEMBER.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883.....	23.	86.	1.	46.	23.	92.	15.	46.	17.	80.	11.	37.
1884.....	2.	87.5	15.	50.5	20.	95.	25.	44.	5.	84.	14.	36.
1885.....	18.	90.5	12.	46.5	1.	89.	28.	45.	27.	83.7	24.	40.
1886.....	7.	95.	1.	45.2	30.	91.5	6.	47.7	11.	89.5	22.	40.
1887.....	8.	95.5	11.	58.7	3.	88.5	8.	46.	22.	81.7	27.	37.2
1888.....	5.	89.8	16.	47.	9.	92.6	23.	48.3	1 & 10	83.	7.	40.
1889.....	11.	90.7	6.	50.5	31.	86.7	16 & 17	50.3	4.	84.	22, 23 & 29	40.
1890.....	9.	94.5	24.	46.5	4.	96.2	24.	46.	8.	83.6	25.	35.5
1891.....	14.	92.	31.	46.	12.	92.	29.	46.5	26.	92.8	30.	43.
1892.....	29.	96.8	2.	46.4	10.	95.5	28.	49.	26.	88.	20.	39.
1893.....	26.	95.5	24.	48.4	11.	94.5	13.	49.	5.	80.	26.	37.4
1894.....	21.	97.	10.	49.6	25.	93.	27.	45.3	4.	90.	26.	33.
1895*.....	8.	94.	11.	52.	11.	88.	22.	44.	4.	94.	15 & 30	42.
1896.....	3.	94.	18.	49.	6 & 7	87.5	29.	44.	12.	95.	23.	36.
1897.....	11.	97.	15.	57.	15.	87.5	21.	46.	11.	98.	21.	37.5
1898.....	4.	96.5	12.	40	24.	90.5	28.	47.	4.	94.	21.	40.5
1899.....	4.	97.5	1.	50.	20.	97.5	15.	44.5	4.	92.	15 & 30	38.
1900.....	17.	96.	1.	50.	11.	90.	2.	51.	12.	95.	19.	37.
1901.....	1.	97.5	20.	54.5	22.	90.	5.	52.	6.	88.	26.	36.
1902.....	14 & 27	90.	31.	53.	31.	90.	13.	47.	1.	90.	15.	38.
1903.....	9.	94.	15.	50.	18.	85.5	8 & 14	45.	14.	90.	23.	35.
1904.....	19.	93.	3.	49.	25.	89.5	19.	46.	3.	88.	23.	33.
1905.....	18.	92.	22.	48.5	10.	91.	27.	41.	30.	88.5	26.	36.
1906.....	20, 22 & 23	89.	25.	50.	6.	98.	16.	47.	18.	91.5	25.	36.
1907.....	16.	90.	3 & 5	50.	12.	96.5	19.	41.5	20.	90.	27.	39.
1908.....	6, 11 & 30.	94.	9.	52.	4.	95.	25.	46.	10.	92.	30.	37.
1909.....	15.	92.	4.	42.	8.	98.	31.	32.	14.	93.	2 & 6	35.
1910.....	9.	96.8	5.	50.	3 & 15	90.	27.	44.	6.	87.	15 & 23	40.
1911.....	5.	105.	25, 26 & 27	50.	8.	94.5	30.	47.	2.	87.	14.	35.

* From data given by Mr. Edgar Parker. Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURE FROM 1883 TO 1911, INCLUSIVE — (Concluded).
(Highest and Lowest Record for each Month in Bold Face Type.)

	OCTOBER.			NOVEMBER.			DECEMBER.		
	MAX.		MIN.	MAX.		MIN.	MAX.		MIN.
	Date.	Temp.		Date.	Temp.		Date.	Temp.	
1883.....	11.	78.	25.	22.	70.	13.	10.	43.	-7.5
1884.....	5.	84.2	17.	23.	62.	15.	31.	55.5	-15.5
1885.....	1.	76.7	27.	23.	63.	18.	24.	53.	4.
1886.....	10.	76.7	17.	28.	68.	17.	11 & 25	46.	-6.
1887.....	9.	78.5	21.2	28.	68.2	15.	12.	54.7	-3.
1888.....	6.	62.7	21.	28.	68.	8.	27.	53.	4.
1889.....	2.	68.7	22.	1 & 3	73.	17.8	25.	60.5	8.
1890.....	5.	69.8	24.	1 & 4	61.7	17.	25.	46.2	3.
1891.....	4.	89.4	31.	8.	65.4	12.	1.	57.7	7.
1892.....	1.	82.	27.	1.	68.	18.	5.	20.	3.
1893.....	13.	76.	33.1	19.	60.	12.	9.	27.	-3.7
1894.....	1.	76.5	31.	3.	62.2	19.	26.	62.	1.5
1895*.....	1.	72.	33.	3.	65.	12.	17.	59.	-0.2
1896.....	30.	77.5	30.	7.	68.	19.	20 & 21	62.	2.
1897.....	16.	88.	29.	19.	70.	19.5	14.	58.	2.
1898.....	1.	85.5	10 & 18	5.	65.	16.5	12.	61.5	3.
1899.....	15.	86.	28.	5.	63.	16.	31.	54.	3.
1900.....	6 & 7	89.	26.	19.	60.	25.	12.	60.	-1.
1901.....	10 & 11	74.	28.	22.	70.	19.	14.	55.	4.
1902.....	19.	74.	28.	14.	73.	22.	2.	52.	5.
1903.....	1.	73.	28.	4.	70.	12.	3.	46.	4.
1904.....	10.	81.	25 & 27	3.	65.	9.	23.	53.	-2.
1905.....	1.	85.	26.	12.	61.	14.	29.	52.5	1.
1906.....	5.	79.5	13 & 31	19.	62.	16.	6.	52.	1.5
1907.....	7.	76.	31.	1.	59.	22.	30.	57.	13.5
1908.....	18.	83.	21.	26.	68.	18.	1.	64.	3.
1909.....	9.	82.5	29 & 30	11.	75.	21.	6.	45.	1.
1910.....	6.	81.	26.	27.	59.	23.	29.	41.	-2.5
1911.....	4.	78.	26.	7.	43.	18.	9.	67.	13.

* From data given by Mr. Edgar Parker. Station record not available.

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1911,
INCLUSIVE.
(Highest and Lowest Record in Bold Face Type.)

	MAXIMUM FOR EACH YEAR.		MINIMUM FOR EACH YEAR.	
	Date.	Temp.	Date.	Temp.
1883.....	Aug. 23.....	92.	Jan. 11.....	-9.
1884.....	Aug. 20.....	95.	Dec. 20.....	-15.5
1885.....	July 18.....	90.5	Feb. 11.....	-11.5
1886.....	July 7.....	95.	Jan. 13.....	-18.7
1887.....	July 3.....	95.5	Jan. 19.....	-8.
1888.....	June 23.....	94.1	Feb. 10.....	-7.
1889.....	May 18.....	91.8	Feb. 4 and 24.....	-7.
1890.....	Aug. 4.....	96.2	March 8.....	2.
1891.....	June 16.....	95.	Feb. 15.....	2.5
1892.....	July 29.....	96.3	Jan. 10.....	-5.
1893.....	July 26.....	95.5	Jan. 11.....	-6.
1894.....	July 21.....	97.	Feb. 27.....	-8.5
1895*.....	June 3.....	96.	Feb. 8.....	-14.
1896.....	Aug. 6 and 7.....	96.	Feb. 17.....	-21.
1897.....	Sept. 11.....	98.	Jan. 20.....	-3.5
1898.....	July 4.....	96.5	Jan. 30 and 31.....	-4.
1899.....	July 4 and Aug. 20.....	97.5	Feb. 11.....	-8.
1900.....	Aug. 11.....	97.	Feb. 27.....	0.
1901.....	July 1.....	97.5	Feb. 24.....	2.5
1902.....	May 22, July 14 and 27, August 31 and Sept. 1.....	90.	Dec. 9.....	-5.
1903.....	July 9.....	94.	Feb. 18 and Dec. 19.....	-4.
1904.....	July 19.....	93.	Feb. 16.....	-18.
1905.....	Aug. 10.....	93.	Feb. 5 and 14.....	-6.
1906.....	Aug. 5.....	93.	Feb. 6 and 7.....	-7.
1907.....	Aug. 12.....	96.5	Jan. 24.....	-18.
1908.....	Aug. 4.....	95.	Feb. 5.....	-14.
1909.....	Aug. 8.....	98.	Jan. 19.....	-7.
1910.....	July 9.....	96.5	Jan. 5.....	-8.
1911.....	July 5.....	105.	Jan. 5.....	-1.

* From data given by Mr. Edgar Parker. Station record not available.

AVERAGE MONTHLY AND YEARLY TEMPERATURE SINCE 1882.

YEAR.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly averages.
1883	17.4	22.3	23.6	43.3	50.	66.6	67.4	65.6	56.3	46.6	39.1	27.5	43.8
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	35.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.	68.	67.5	61.8	49.6	36.8	22.2	45.6
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	63.	57.7	47.	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	63.	62.2	43.9	39.4	29.3	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.	60.5	44.	39.4	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.3	50.	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	66.8	58.	52.	36.	27.5	45.3
1894	29.7	20.9	38.9	44.1	55.5	67.8	74.2	71.2	64.8	52.7	39.6	31.4	48.6
1895	21.8	16.9	26.9	44.4	59.	65.9	71.4	70.	61.7	45.4	39.6	31.4	48.
1896	22.4	24.1	24.4	49.3	62.	62.3	73.6	67.6	62.3	56.5	42.9	27.1	47.6
1897	23.2	26.1	33.8	45.	55.4	67.7	74.2	71.6	65.9	52.6	39.7	29.2	47.
1898	26.2	26.8	.....	43.2	57.	69.5	71.2	71.6	60.6	53.4	38.9	30.	47.7
1899	22.1	20.4	30.4	46.6	57.6	68.4	72.6	71.6	64.	57.9	41.1	28.7	48.5
1900	26.	22.6	23.6	43.5	56.7	68.9	76.6	67.6	63.6	43.1	46.3	27.7	47.9
1901	26.1	18.5	32.2	46.5	56.1	63.2	71.2	65.5	64.4	52.5	36.2	25.3	45.2
1902	23.2	22.2	39.5	46.6	56.1	63.2	70.8	68.2	61.9	48.4	36.9	22.5	45.9
1903	25.7	26.1	42.4	45.9	60.4	67.8	70.8	68.2	67.3	52.4	37.6	32.	47.4
1904	18.9	23.1	30.9	41.4	60.3	67.8	71.8	68.4	64.4	51.2	37.9	26.1	48.8
1905	32.5	26.1	33.1	46.4	57.5	68.2	71.4	72.8	67.3	48.4	38.7	31.8	46.7
1906	19.8	18.9	27.6	44.8	57.5	68.4	71.8	68.4	67.3	47.9	44.5	25.7	48.1
1907	24.9	19.5	36.1	40.2	51.3	64.	73.4	68.4	64.4	52.9	40.	25.7	47.9
1908	25.9	21.3	34.6	44.8	59.2	68.8	73.4	68.4	67.	47.7	44.5	25.7	48.1
1909	27.7	28.6	31.	44.3	57.9	67.2	73.1	69.	63.5	53.1	35.7	25.7	47.9
1910	25.1	22.1	42.1	50.1	64.9	65.2	73.1	69.	63.5	53.1	35.7	25.7	47.9
1911	27.9	26.6	30.9	44.8	64.9	67.5	74.4	70.9	62.8	50.7	36.6	35.1	49.4

METEOROLOGICAL RECORDS.

PRECIPITATION BY RAINFALL ONLY BY MONTHS SINCE 1882.

YEARS.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1882	Inches. 0.48	Inches. 1.44	Inches. 0.88	Inches. 1.58	Inches. 4.43	Inches. 3.69	Inches. 2.42	Inches. 2.37	Inches. 1.25	Inches. 0.62	Inches. 1.22	Inches. 0.53	Inches. 25.89
1883	1.83	2.01	2.54	0.63	2.49	4.12	2.98	3.47	2.12	2.10	1.54	0.73	22.30
1884	1.07	0.61	0.12	1.26	1.68	2.01	2.33	1.44	3.17	2.10	1.01	0.97	23.90
1885	1.13	0.95	1.13	4.13	1.92	2.92	4.64	5.02	2.11	2.88	1.86	0.76	27.87
1886	0.18	2.17	0.48	1.87	0.46	2.01	6.87	2.80	2.81	1.89	3.48	1.24	21.49
1887	0.78	1.04	1.43	3.09	2.79	3.88	0.99	3.03	0.75	1.74	1.56	1.35	27.48
1888	2.99	0.25	0.66	3.28	1.21	7.47	4.57	4.98	2.73	3.47	2.02	1.24	36.29
1889	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	2.50	3.32	3.44	1.62	27.53
1890	1.44	1.57	3.25	1.63	0.49	4.31	3.62	3.16	0.47	3.05	0.74	3.29	23.17
1891	0.57	0.88	0.55	0.67	4.04	3.05	1.89	4.77	1.12	1.34	2.07	0.72	33.84
1892	1.62	3.71	1.94	2.59	4.92	3.08	3.08	5.38	2.08	1.99	1.09	1.56	29.36
1893	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.04	3.99	0.43	0.47	27.61
1894	0.96	...	0.29	1.33	2.88	...	...	2.06	0.94	0.72	2.31	2.49	23.78
1895	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	28.40
1896	0.94	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.58	1.39	19.35
1897	0.83	0.83	1.54	2.03	1.90	2.39	1.32	3.60	1.86	3.83	2.08	0.33	27.73
1898	1.74	0.37	0.30	1.22	1.12	1.71	4.15	1.05	2.23	3.05	1.36	0.78	26.89
1899	0.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	2.46	0.74	0.74	38.69
1900	0.72	...	2.19	4.43	3.80	2.07	3.97	5.02	2.46	1.35	2.09	0.71	32.38
1901	0.86	0.66	1.94	1.92	2.84	4.33	6.25	2.41	2.38	4.19	1.68	0.38	29.93
1902	1.81	1.11	5.60	2.60	0.23	7.77	4.86	2.21	1.30	2.06	1.32	1.42	24.73
1903	0.80	1.03	2.41	1.67	4.04	3.37	6.73	2.56	1.90	3.06	1.40	1.64	24.06
1904	0.40	0.27	1.09	2.08	2.01	8.76	3.39	3.48	2.16	3.48	2.78	0.43	20.87
1905	1.46	0.53	1.90	2.42	1.24	6.31	2.95	3.08	2.73	2.73	0.68	0.49	25.12
1906	1.89	0.03	1.14	1.82	1.82	2.34	2.95	1.35	1.95	1.18	0.56	0.38	26.25
1907	0.68	1.23	1.32	3.40	2.82	2.17	2.13	2.51	3.29	2.37	1.41	2.08	...
1908	0.87	0.83	0.25	4.50	3.33	1.55	2.30	5.47	3.21	...	...	...	...
1909	0.87	0.24	1.07	3.24	1.36	2.51	4.49	3.36	...	...	...	...	...
1910	0.91	...	...	...	...	...	...	...	...	...	...	...	...
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